

# Pineapple News

Issue No. 14 Newsletter of the Pineapple Working Group, International Society for Horticultural Science May, 2007

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## News of General Interest, Pineapple Working Group News

### *Dear Colleagues:*

The past year has been an interesting one for me. In the past 10 months, I have had the pleasure of visiting pineapple farms and plantations in Ghana, Sumatra, and Taiwan. Travel to Ghana was memorable because I was able to see the results of an effort to almost completely change cultivars in a very short time span and some field operations were unique because they were done by hand whereas elsewhere machinery is used. I share with you readers some the Ghana experiences because I found them so interesting. The people of Ghana were friendly, helpful and technically competent, which made the experience even more memorable. I mentioned how friendly I found the people of Ghana to be to the man assigned as a driver while we visited three pineapple farms. He replied "In Ghana if you see someone, even if you don't know them, you must greet them. It is our culture." I thoroughly enjoyed the food, the people, and the discussions about pineapple production in their conditions and climate.

While pineapple farming seemed to be an expanding enterprise in Ghana, here in Hawaii it was a rapidly contracting one. Del Monte Fresh Produce Hawaii Inc. closed more than a year ahead of the scheduled closure date and Maui Pineapple Company recently announced the closure of the only remaining pineapple cannery in Hawaii. See "News From the United States" for some additional details.

### ***Rapid Expansion of MD-2 Pineapple Production in Ghana***

In June of 2006 I was invited to accompany Mr. Faruk Ghumra of A1 Fruit in England on a trip to visit a few pineapple growers in Ghana. A1 Fruit was exploring the possibility of importing pineapples from Ghana for use in cut fresh packs. Several growers in Ghana had rapidly expanded production of the Pineapple Research Institute of Hawaii (PRI) hybrid 73-114. Del Monte Fresh Produce Inc. named the hybrid MD-2 for internal use also used the name when the hybrid was first sold in commercial quantities in the United States and Europe. As a result, this hybrid is known almost universally by growers throughout the world as MD2. The objective of our trip to Ghana was to examine some fruit quality issues with the hybrid and Mr. Ghumra wanted to acquaint the Ghanaian growers with the extensive field and packhouse standards of the English supermarkets that would be marketing the fruit. I have included some additional comments on farming practices seen in use on the farms we visited.

For many years, the main pineapple cultivars grown in Ghana were 'Smooth Cayenne' and 'Queen' (Queen Victoria and Sugarloaf). Beginning in 2002, Ghana farmers set out to rapidly expand production of MD2 because market demand for 'Smooth Cayenne' fruit from Ghana had dropped sharply after MD2 won the major market share in Europe. Production of the hybrid was expanded rapidly in Ghana as a result of coordinated efforts of government and private agencies. For details, please see <http://www.gepcghana.com/news.php?item=4&n=>. This joint effort included the construction of a modern tissue culture laboratory at Bowmarts Farms for rapid propagation of MD2 plants (Figure 1). However, tissue culture was too costly to provide all the planting material needed to meet current and projected grower demand. To further increase the supply of plants, tissue-cultured plants were planted in field nurseries and, when well established, were gouged (see Pineapple News 13 for details on this method) to promote the development of shoots (suckers) on the stem. After reaching the desired size, the suckers were harvested and planted in the field.



Figure 1. Tissue culture laboratory at Bowmarts Farm and plants produced in the laboratory in the nursery and ready to be planted in the field.



A disadvantage of meristem propagation is that the somaclonal variation in pineapple results in the production of varying numbers of obvious off-types (Figure 2). The most obvious variants in the MD2 populations seen in Ghana were plants with spiny leaves, multiple and fasciated crowns, variable slip numbers and a small number of plants with variegated leaves. It is impossible to say how many other less obvious variants were present in the population. Because of the desire to increase the supply of MD2 plants as rapidly as possible, no roguing of off-type plants was done though some spoke of plans to rogue off-types at some future time.



Figure 2. Off-type plants arising from meristem culture of MD2 plants.

Additional MD2 planting material, mostly suckers, for use in replanting or expanding MD2 production was harvested from plants after the fruits were harvested. The common practice used was to hand-slash the plants with a machete to a height of about 30 cm and then harvest the suckers when they reached the desired size. It isn't clear why hand slashing, a practice also used on some plantations in Hawaii, is done but it is assumed that it makes it easier to harvest the suckers. Slashing removes significant amounts of leaf area but it may be that the remaining leaves and stem starch reserves are sufficient to produce the desired numbers of suckers. No references were found on the subject so it seems to be a topic that warrants further study.

Three of the four farms we visited grew pineapple on fields with varying slopes, some of which were quite steep. Most pineapple was planted across the slope to reduce soil losses by erosion and some fields also included grassed waterways. Despite these measures, there was still significant erosion in some fields. If no additional effort is made to control erosion, it could become a serious problem on steeper lands (Figure 3).



Figure 3. Landscape in pineapple growing area in Ghana and water-eroded area in a similar field.

Cultural practices in growing MD2 pineapple in Ghana were similar to those used for 'Smooth Cayenne'. On at least one farm, elimination of the previous crop involved allowing the accumulated pineapple plants and weeds to dry during the dry season after which the field was burned to clear it. Burning also destroyed any remaining plastic mulch. Tillage was mostly with a disk plow though on one farm a moldboard plow was used followed by power spading. The latter machine did a good job of breaking up soil clods and, because it tilled to a depth of about 30 cm, also improved drainage. Ridging was done in all fields to improve drainage followed by application of black plastic mulch, which was said to reduce evapotranspiration during the dry season and it also reduced weed control problems.

Fertilization practices were typical of those found in most countries except the spray solution was applied with backpack sprayers rather than with tractor-drawn or self-propelled boom sprayers scaled to the size of the farm. The backpack sprayers were refilled from a tractor-drawn nurse tank. The decision to use such labor-intensive methods was due to low cost of labor, about U.S. \$2.00 to \$2.25 per day, rather than to a lack of technology. Practices were mechanized where they could be used effectively.

Plants in the field had good color and looked very healthy but anchorage was poor, reflecting the near absence of roots on many plants. It was assumed that was a reflection of the greater susceptibility of MD2 plants to *Phytophthora* root rot, but perhaps other organisms are involved as well. The exception to the excellent appearance of most plants were a few small areas with fairly severe iron chlorosis. The growers said the areas of iron deficiency marked the location of old termite mounds. A “calcium collecting tree” (*Chlorophora excelsa*), locally called odum, reportedly can produce neutral to alkaline soils beneath it, which makes one wonder if the areas of iron chlorosis were where such trees had once been growing.

MD2 is known to be much more sensitive to natural induction of flowering than is ‘Smooth Cayenne’ and thus is easy to force. However, to insure a high percentage of forcing, double forcing was done. Either a solution of calcium carbide and water was applied twice at one or two-day intervals or an ethylene-water solution was used, followed by a second application of either ethylene or calcium carbide. When fruits had reached the desired maturity, they were picked and placed into plastic crates. The crates were then loaded on trucks or tractor-drawn trailers and driven to the packing shed. In all but one case, packing sheds were simple, fruits were handled individually, and in most cases were packed without waxing (Figure 4).



Figure 4. Picking MD2 fruits into plastic crates, cleaning and packing fruits in the packing shed, and boxed fruits on the pallet ready to be strapped for shipping.

The area planted to MD-2 on the farms visited was quite large, probably approaching 500 ha, and some growers planned to continue expanding the area planted to MD2. The growers were doing a good job of meeting the challenges associated with growing a new pineapple hybrid with its unique problems. It is likely that assistance from the Pesticides Initiative Program (PIP) implemented by COLECAP (Europe-Africa-Caribbean-Pacific Liaison Committee; <http://www.colecap.org/>) increased their chances of success. Included in the assistance provided by PIP was an MD2 production manual that was written by consultants from Costa Rica where the hybrid is extensively grown.

The major fruit quality issues encountered were undersized fruit, which appeared to be mostly associated with forcing plants that were too small to produce the desired fruit size. Presumably because of the warm tropical environment, fruit flesh quality was not comparable to MD2 fruit produced in Hawaii's cooler environment. Fruit flesh Brix on the few fruits sampled was quite adequate, ranging from near 14 to 17, but flesh color of this “gold” hybrid was pale, acidity was low and flavor was lacking. The climate of Ghana is tropical and, based on two-years data from one farm, the average temperature was 27 °C and no monthly average was below 23 °C. Such warm temperatures promote rapid vegetative and reproductive growth of pineapple and are known to result in low levels of acidity and carotenoids. As a result of the warm temperatures, the crop cycle, which for the growers we visited begins with suckers weighing between 300 and 500 g, is only one year; no ratoons were harvested on the farms we visited. Annual variation in days from forcing to harvest for ‘Smooth Cayenne’ in Ghana ranged from 130 to 135 as contrasted with 180 to 220 days in the cooler Hawaii environment. The comparable range for MD2 was said to be 125 to 130 days.

## 6<sup>th</sup> International Pineapple Symposium

Planning for the 6<sup>th</sup> International Pineapple Symposium scheduled for November 2007 in Joao Pessoa, Brazil continues and some additional information on hotel accommodations has recently been added to the symposium web site. You can find the symposium we at <http://www.ipsbrasil2007.com.br>.



## ISHS

As you have read here before, the ISHS is one of the foremost organizations promoting cooperation and communication among researchers, growers and consumers in the horticultural industries. The ISHS provides the structure under which our Pineapple Working Group functions and provides for the publication of meeting proceedings in a volume with high visibility. An important benefit of membership is to support an organization with the goal of improving horticulture across the globe. Detailed information about ISHS and the benefits of membership can be found at <http://www.ishs.org> or you can write to the ISHS Secretariat, P.O. Box 500, 3001 Leuven, Belgium (E-Mail: [info@ishs.org](mailto:info@ishs.org)).

## News From Australia

### Pineapple Seed Germination

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Several approaches to the germination of pineapple seed have been published by different authors. Benega *et al* (1997) found a solution of MS salts and vitamins or distilled water the best for germinating seed. Luz *et al* (1999) found soaking seed in water for 8 h a better pre-treatment for germination than 2% sodium hypochlorite for 2.5-15 min. Cabot *et al* found formaldehyde vapours the best for disinfecting seed followed by germination at 24 °C on a gel media without salts or vitamins. Williams (1969) reports germination is best if seed is scarified in 50% H<sub>2</sub>SO<sub>4</sub>, rinsed in water, surface dried then disinfected by moist autoclaving in sand media and held under 100 ft candles light at 32-35 °C. A range of different methods for disinfecting and germinating seed are therefore reported. Here, a reliable aseptic technique for the germination and early growth of potentially weak inbred seed was required. A series of simple experiments were therefore conducted to verify the parameters including sanitisation, temperature, light and culture media.

#### Seed sterilisation

Seed were subjected to one of six treatments before placing in a sterile growth media in 5.5 cm petri dishes and incubated under continuous light (21 M m<sup>-2</sup> s<sup>-1</sup>) at a constant temperature of 28 °C. Three petri dishes, each containing 50 seed, were subjected to each treatment. Seed were considered germinated when the length of the emerged radicle exceeded 1mm. Data in this and the other experiments reported here were analysed using 1-way ANOVA in Genstat v8.1. The treatments and results are shown in Table 1.

Table 1. Seed sterilisation treatments and germination data.

NaOCl (w/v)	1.5% PPM <sup>†</sup>	Other	Max Germination, 50 DAP (%)
3% for 15 min	Nil	Overnight in sterile water	68 b <sup>†</sup>
3% for 15 min	Overnight	Nil	70 bc
3% for 15 min	1 hr	Nil	88.3 c
3% for 5 min	Nil	Overnight in sterile water	C*
3% for 5 min	Overnight	Nil	73.3 bc
3% for 5 min	1 hr	Nil	79.7 bc
1% for 5 min	Overnight	Nil	C*
1% for 5 min	1 hr	Nil	48.3 a
Nil	Overnight	Nil	63.3 ab
Nil	Nil	Overnight in sterile water	C*
Isd			18.5

<sup>†</sup>Plant Preservative Mixture™

<sup>†</sup>Means followed by a common letter are not significantly different from each other based on the Isd.

\*Contaminated.

Each 50-seed sample was placed in a sterile 10 mL plastic tube before treatment. Seed immersed in sodium hypochlorite (NaOCl) solution were then rinsed 3 times with 10 mL of sterile distilled water before soaking in either sterile distilled water or 1.5% (v/v) Plant Preservative Mixture (PPM™ – Product P820 PhytoTechnology Laboratories) for 19-20 hr. The seed were then transferred to folded squares of sterile blotting paper before embedding into Orchid Seed Sowing Media (Product No. P723 PhytoTechnology Laboratories) containing 1 mL L<sup>-1</sup> of PPM. All work was performed in a laminar flow cabinet following aseptic procedures.

Treatment with a 1% NaOCl solution (w/v) for 5 min was not completely reliable. A 15 min soak in a 3% solution (w/v) was necessary to ensure sufficient sanitisation of pineapple seed, and also stimulated germination, probably through scarification of the seed testa. Additional treatment with 1.5% PPM<sup>TM</sup> for 1 hr also improved germination. PPM<sup>TM</sup> was not, however, totally reliable for removing endogenous contamination in pineapple seed when used at 1.5%. The best treatment was the 3% NaOCl treatment followed by a 1 hr soak in 1.5% PPM<sup>TM</sup>. The use of a growth media containing 1 mL L<sup>-1</sup> of PPM was essential for suppression of endogenous contamination not removed by the sterilisation treatment.

### Effect of temperature

Seed were soaked in 3% NaOCl solution as described above for 15 min, rinsed 3 times in sterile distilled water, and then soaked in 1.5% (v/v) PPM<sup>TM</sup> for 19-20 hr. The seed were embedded into Orchid Seed Sowing Media in 5.5 cm petri dishes and incubated under continuous lighting (27 M m<sup>-2</sup>s<sup>-1</sup> supplied by 'GroLux' florescent tubes) on a thermal gradient plate. The thermal gradient plate was divided into 10 separate 'plexiglass' cabinets and the temperature of each cabinet was held constant. Three petri dishes, each containing 20 seeds, were placed in each cabinet. Seeds were considered germinated when the length of the emerged radicle exceeded 1mm. The treatments and results are shown in table 2.

Table 2. Temperature treatments and germination data.

Temperature (°C)	Germination, 30 DAP, %	Germination, 64 DAP, %
22	0 a <sup>†</sup>	35 a
26	18 abcd	77 e
27	29 bcd	68 cd
29	37 de	76 e
31	31 cd	75 e
32.5	55 e	89 e
33	35 d	73 de
34.5	25 bcd	65 c
35	10 ab	56 bc
37	16 abc	52 ab
lsd	19.2	20.0

<sup>†</sup>Means followed by a common letter are not significantly different from each other based on the lsd.

The first seed had germinated by day 20 and germination had occurred at all temperatures by day 30. Germination percentages were similar for temperatures in the range 29-32 °C in the first 30 days after planting (data not shown). By day 60 there were no additional seed germinating. Germination was most rapid and complete at 32 °C with a maximum of 89% of seed germinating. The optimum temperature for pineapple seed germination appears to be approximately 32 °C. Good results could however be achieved in the range 29-33 °C, which is within the optimum range reported by Williams (1969).

### Effect of light

Seed were treated and placed into culture as for the temperature experiment then placed at a constant temperature of 28 °C under either continuous light (21 M m<sup>-2</sup>s<sup>-1</sup>) or in the dark. There were 12 petri dishes each containing 10 seed in both the 'light' and 'dark' treatments. The 'dark' treatment was imposed by wrapping the petri dishes in aluminum foil. These seed were however exposed to light for a few minutes every day or so during counting. Seeds were considered germinated when the length of the emerged radicle exceeded 1mm.

Seed in the 'light' treatment commenced germinating at 19 days after planting. Germination was considered complete by day 62 when approximately 69% of the seed in the 'light' treatment had germinated. At that time, only 10% of the 'dark' seed had germinated and 'dark' seed germinated in only 3 of the petri dishes.

The exclusion of light inhibits germination of pineapple seed. The level of light to which the 'light' seed were exposed was low and it was further reduced by the fact the seed were embedded into agar containing charcoal. It is concluded that a low level of light is essential for maximum germination of pineapple seed. This is in agreement with Williams (1969) who also adds that pineapple seed will actually germinate in darkness if subjected to fluctuating temperature, and for that purpose, 23-32 °C works best. The results indicate that seed being germinated in a nursery situation should be planted on the surface of the potting media or at a shallow depth.

### Effect of culture media

Seed were treated as for the temperature experiment but soaked in 1.5% (v/v) PPM<sup>TM</sup> for only 1 hr. The seed were then embedded in their respective media treatment and incubated under continuous light at 30 °C. There were 6 petri dishes per treatment, each containing 20 seed. The treatments and results are shown in table 3.

Table 3. Culture media treatments and germination data.

Treatment	Phytigel <sup>TM*</sup>	Sucrose g L <sup>-1</sup>	MS <sup>†</sup> medium	Germ, 24 DAP	Germ, 35 DAP
25% MS	2	5	1.1	74.2 a <sup>‡</sup>	88.3 a
50% MS	2	10	2.2	60.8 b	87.5 a
100% MS	2	20	4.4	38.3 c	87.5 a
Orchid media <sup>**</sup>				22.0 d	46.7 b
Isd				11.7	10.1

\*Sigma-Aldrich Biotechnology agar substitute gelling agent, product P8169.

<sup>†</sup>MS, Murashige & Skoog basal media plus vitamins. PhytoTechnology Laboratories product M519.

<sup>‡</sup>Means followed by a common letter were not significantly different based on the Isd.

<sup>\*\*</sup>Orchid Media is PhytoTechnology Laboratories product P723 (contains agar, vitamins and minerals but no sucrose).

Each media contained 1 mL/L of PPM<sup>TM</sup>.

The orchid seed sowing media produced the least germination maximum (35 DAP) and the slowest germination rate (24 DAP). The lower the strength of MS media, the faster the germination but all MS media treatments reached a similar maximum after approximately 35 days. However, the 25% strength MS media using Phytogel did not have sufficient cations to solidify fully so is not ideal. Agar could be used instead of Phytogel or the concentration of the Phytogel could be increased slightly.

### Acknowledgements

The author would like to thank S. Hamill for advice on the sterile culture techniques.

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## The Role of Insects in the Pollination of Pineapple in Australia

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### Introduction

Hummingbirds are considered to be the predominant pollinators of Bromeliaceae in the countries where they both naturally occur (Coppens and Leal, 2003). Wind pollination is not known to occur in pineapple, as there is no wind movement of pollen (Kerns *et al*, 1968). Pineapples are however, grown commercially in many countries where hummingbirds do not exist but seed set does occur (Paull and Chen, 2003). For example, in the absence of hummingbirds, no apparent natural vectors are thought to exist in Hawaii (Collins, 1960). Honeybees visit pineapple flowers in Hawaii but it is assumed they are sourcing nectar that has seeped out between the petals (Purseglove, 1975). Wee and Rao (1974), however, claimed sporadic cross-pollination occurs in Malaysia with the help of honeybees and pineapple beetles *Nitidulid* spp. The role of honeybees in the pollination of pineapple in Australia is unclear. Pollination, and hence seed set in pineapple does occur in Australia and in other pineapple producing countries (Paull and Chen, 2003) and is commercially undesirable.

Pineapple flowers are hermaphroditic with most commercial cultivars being highly self-incompatible. Seed is therefore rare in monoclonal fields and is only produced through cross-pollination, due to a low level of self-compatibility in some varieties or the spontaneous mutation of some plants to self-compatible genotypes (Chan *et al*, 2003; Paull and Chen, 2003). Pollinating vectors and nearby genetically compatible varieties are required for substantial seed development in most commercial varieties.

This study aimed to establish if honeybees were implicated in the pollination of pineapple in Australia with observations on bee activity, pollen identification and seed development in a research plot at Nambour in southeast Queensland.

### Materials and method

Twenty-seven flowering syncarps were monitored for 10 mins each over 5 days, between 0600 and 1530 h, and the identity and activity of the insects that visited open flowers recorded. Eleven honeybees visiting the flowers and that were carrying pollen were captured and the pollen removed for later identification.

A comparison of different combinations of flower protection and artificial pollination was also conducted using the Pineapple Research Institute of Hawaii hybrid 73-50. The four treatments included, open pollination, protected and self-pollinated, protected and cross-pollinated with 'Smooth Cayenne' and, protected only. Inflorescences were protected by covering with sleeves made of fine gauze material. A hive of honeybees was moved adjacent to the field at mid-anthesis. There were 10 plants per treatment and the results were analysed using a randomised block design ANOVA model in Genstat (8<sup>th</sup> edition).

## Results

The predominant insects visiting the pineapple flowers were honeybees (Table 1). Most visited the outside of the flower, usually the base of the petals, although some did probe with their proboscis between the longitudinal edges of the petals without entering the flower (Fig. 1A). Forty-three percent of bees entered the flower, inserting at least the head, but sometimes the thorax (Fig. 1B). Sixty-three percent of the honeybees that entered the flower had pollen in their pollen sacs. This pollen was identified as pineapple pollen. One bee, seen visiting the outside of flowers, carried pollen (Table 1). Native bees, *Trigona* sp. also visited the flowers but, almost all did not enter. A small number of other insect visitors were recorded, including ants and flies. The noisy miner bird (*Manorina melanocephala*), a perching nectar feeder, also visited the flowers.

Table 1. Insects observed visiting pineapple flowers.

Insect	Entered flower		Did not enter flower	
	With pollen*	No pollen	With pollen	No pollen
Honeybee	24	13	1	48
<i>Trigona</i> sp.	0	1	0	22
Other spp.	0	0	0	5

\*'With pollen' refers to the number of insects obviously carrying pollen.

Open pollination produced more seed than protected and self-pollinated fruit indicated cross-pollinated had occurred where potential pollinators were not excluded (table 2).

Table 2. Effect of hand pollination and open pollination on seed development.

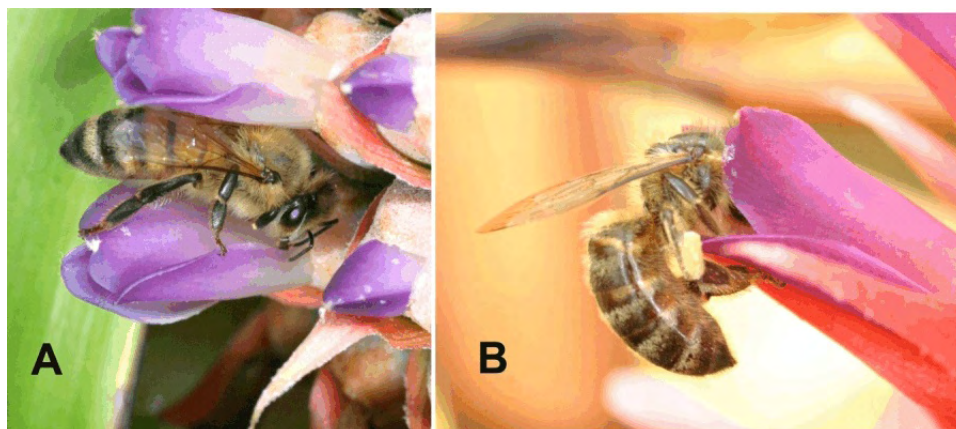
Treatment	No. seed/fruitlet	Seed wt (g/100 seed)
Open pollinated	0.93 b <sup>†</sup>	0.29 a
Cross pollinated	4.34 a	0.31 a
Protected	0.00 c	
Self-pollinated	0.01 c	0.13 b
lsd	0.76	0.08

<sup>†</sup>Means followed by a common letter are not significantly different based on the lsd.

## Discussion

Honeybees will enter pineapple flowers and collect pollen. This together with an accessible stigma suggests pollination is highly likely. It is possible that honeybees that entered a flower were seeking nectar, and the adherence of pollen to their body was accidental.

Most bees that visited pineapple flowers did not enter the flower. It is likely these bees were seeking nectar. When nectar flow is heavy, it may rise to the mouth of the corolla tube and seep laterally between the petals and sepals and collect on the sepal and bract surfaces (Okimoto, 1948). Honeybees could therefore obtain nectar between the petals or at their base on the sepal surfaces, or in the case of a full flower, by partially entering the flower. So while some honeybees were entering flowers and





possibly causing pollination, most were collecting nectar from outside the flower and hence, in a biological sense, could be considered as robbers. The dual role of some species of bee as robbers and pollinators has been documented for other plant species (McDade and Weeks, 2004).

Seed can occur in self-incompatible varieties of pineapple grown in mixed varietal blocks at Nambour, Australia in the absence of hummingbirds. Honeybees are the main suspected pollinators of pineapple in Australia.

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## Skin Russeting in the Pineapple Variety 73-50

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### Introduction

The Pineapple Research Institute of Hawaii (PRI) hybrid 73-50 (Chan et al., 2003) is the main fresh market pineapple variety in Australia. Skin russeting occurs in this variety and appears to be seasonal with the greatest incidence occurring in crops flowering in summer and harvested in autumn to winter.

There are several possible causes of skin russeting in pineapple. Fruit on boron deficient plants develop cracks mainly between the individual fruitlets before blossoming and cork tissue forms over these cracks (Broadley et al. 1993), (Figure 1). Interfruitlet corking (IFC) produces symptoms similar to mild boron deficiency. IFC is caused by infection of the developing inflorescence with *Fusarium* or *Penicillium* sp. Infection with either of these pathogens is thought to be associated with damage caused by mites feeding on the trichomes of the developing inflorescence (Rohrbach and Johnson, 2003). Like boron deficiency, the resultant russeting is usually confined to the interfruitlet tissues.

Russeting has been attributed to a range of other factors in other crops. These include sunburn and an accompanying photobleaching in apple (Wunsche et al, 2004), high solar irradiance and high temperature in loquat (Avidan and Klein, 1998), hot, humid, overcast conditions in banana (Campbell and Williams, 1976), thrip infestation in banana (Swaine and Corcoran, 1975), wind damage in citrus (Freeman, 1974), and a fungal pathogen in apricot (Covey, 1976).

### Material and Method

A field of commercially grown pineapple cv.73-50 was used. The planting was situated on a site with a known history of russeting. A randomised complete block design was imposed with 4 replications of 5



Figure 1. Severe russeting on fruit of hybrid 73-50 suspected of being due to boron deficiency.

treatments (Table 1) with 30 plants per plot. The plants were subject to the standard cultural operations used for commercial pineapple production. This includes an application of borax ( $10 \text{ kg ha}^{-1}$ ) at flower induction but does not include any miticide sprays.

**Table 1.** Treatment descriptions.

Treatment	Description
Control	Nil
Boron	3 supplemental boron sprays ( $0.5 \text{ g L}^{-1}$ Solubor) were applied from mid-anthesis at approximately monthly intervals. Approximately $40 \text{ mL plant}^{-1}$ was applied by hand-held sprayer to the crown, fruit and leaves.
Miticide	3 miticide sprays ( $1 \text{ g L}^{-1}$ dimethoate) were applied at approximately fortnightly intervals from approximately 1 month prior to open heart. The solution was applied by hand-held sprayer to the plant heart and developing inflorescence.
Sleeves	Brown paper sleeves were placed over each inflorescence at mid-anthesis.
Shredded Paper	Shredded paper was placed in the throat of the plant when the first sign of inflorescence emergence was observed. This was adjusted periodically up to anthesis to ensure good coverage of the developing inflorescence.

The field was artificially induced to flower in November (late spring). Open-heart in many plants occurred in early summer (122 days before harvest) and mid-anthesis in mid-summer. Five syncarps from plants just past the open-heart stage were collected from plants in the same field but just outside the trial and inspected for the presence of mites. This collection was done prior to any miticide sprays. No mites were observed.

Fruit were harvested when approximately a quarter colour. At harvest, fruit firmness was measured using a penetrometer (Effigi, model FT327) with a 1 cm diameter plunger. Three readings were taken equidistant around the circumference at a point midway up the fruit and a mean calculated for that fruit. Translucency was rated on a scale of 1 (opaque) to 4 (fully translucent). Crown damage was rated on a scale of 1 (normal) to 3 (severely damaged). Data were analysed using the Linear Mixed Models procedure in Genstat v8.1. Air temperature for the approximately 8-week period before harvest is shown in Figure 2. The data are included to provide as much information about prevailing environmental factors as possible, not to imply that a relationship exists between air temperature and fruit russetting.

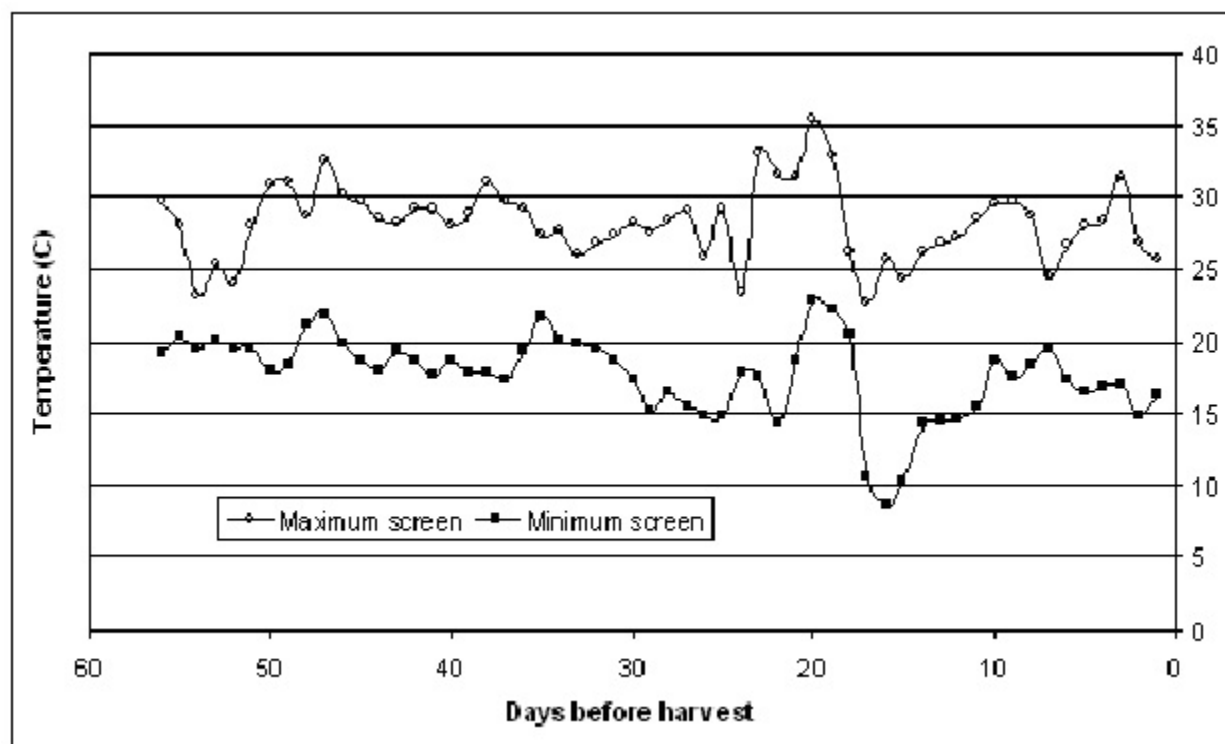


Figure 2. Air temperature data at the experimental site for the approximately 8 weeks prior to harvest. The first sign of russetting on fruit in some plots occurred approximately 43 days before harvest.

## Results and Discussion

### Yield

Both the shredded paper and sleeves treatments (Table 2) were harvested 1-2 weeks earlier than the other treatments yet the fruit from those treatments were heavier, in the case of Shredded paper significantly so, than the other treatments. Fruit weight was 27% greater where the fruit were protected with shredded paper and both treatments where the fruit was protected had fruitlet weights significantly greater than those in the other treatments (Table 2). Fruit shape ratings (data not shown) indicated the sleeve and shredded paper treatments tended to have many fruit with a more square-shouldered appearance. This suggests the increase in fruit weight was also slightly attributable to greater development of the fruitlets at the distal end of the fruit. The increase in fruit weight was also accompanied by a very slight increase in translucency. This difference was very minor and of no commercial importance but would have biased the weight of those fruit slightly.

Table 2. Yield determinants.

Treatment	Fruit wt (g)	No. fruitlets (g)	Fruitlet wt (g)	Crown wt (g)
Control	1300 c	84.8 a	15.1 b	238 a
Boron	1431 bc	89.1 a	15.9 b	235 a
Miticide	1324 c	87.7 a	14.9 b	241 a
Sleeves	1540 ab	89.9 a	17.1 a	221 a
Shredded Paper	1648 a	88.6 a	18.2 a	235 a
Lsd	156.5	5.9	1.3	34.4

Data in the same column not followed by the same letter are significantly different at the P=0.05 level.

Table 3. Fruit quality determinants.

Treatment	% fruitlets russeted	Crown damage	TSS (%)	Translucence	Firmness (kg/cm <sup>2</sup> )
Control	9.9 a	1.4 a	13.1 b	2.1 b	11.4 a
Boron	9.2 a	1.4 a	13.2 b	2.2 ab	11.0 ab
Miticide	9.4 a	1.3 ab	13.1 b	2.1 b	11.2 ab
Sleeves	0.3 b	1.2 b	13.8 a	2.3 a	10.8 b
Shred. paper	1.5 b	1.4 ab	13.3 ab	2.2 ab	10.9 ab
Lsd	4.8	0.2	0.62	0.16	0.47

Data in the same column not followed by the same letter are significantly different at the P=0.05 level.

### Fruit quality

There were fewer russeted fruitlets (Figure 3) in the sleeves and shredded paper treatments than in the other treatments. Boron and miticide treatments did not reduce russetting. The russetting observed in this trial was occasionally accompanied by photobleaching and was often more prevalent on the eastern side of the fruit. The general appearance of the russetting, and response to the shredded paper and sleeves treatments suggests the russetting is a symptom of high irradiance or high temperature. Spiegelberg (1960) in a study on the effect of a range of fruit coverings on pineapple fruit temperature found that the colour of the bag was important for reducing fruit temperature. White paper bags were found to be more effective than brown or black bags but all reduced fruit temperature. It is therefore suggested, though not demonstrated, that the brown paper bags used in the present study would most likely have reduced fruit skin temperature.

The data here suggests most of the russetting damage might have occurred post-anthesis. The young developing inflorescence is covered with a dense layer of waxy trichomes and is most likely well-protected at least up to this stage of development. This covering is less evident post-anthesis. The data indicates the shredded paper treatment did offer some protection to fruit post-anthesis but was insufficient to protect crowns. The fact that sleeves protected crowns more than shredded paper indicates crown damage occurred mainly after anthesis but before fruit had enlarged substantially as crowns would have been exposed as they extended out of the sleeves.

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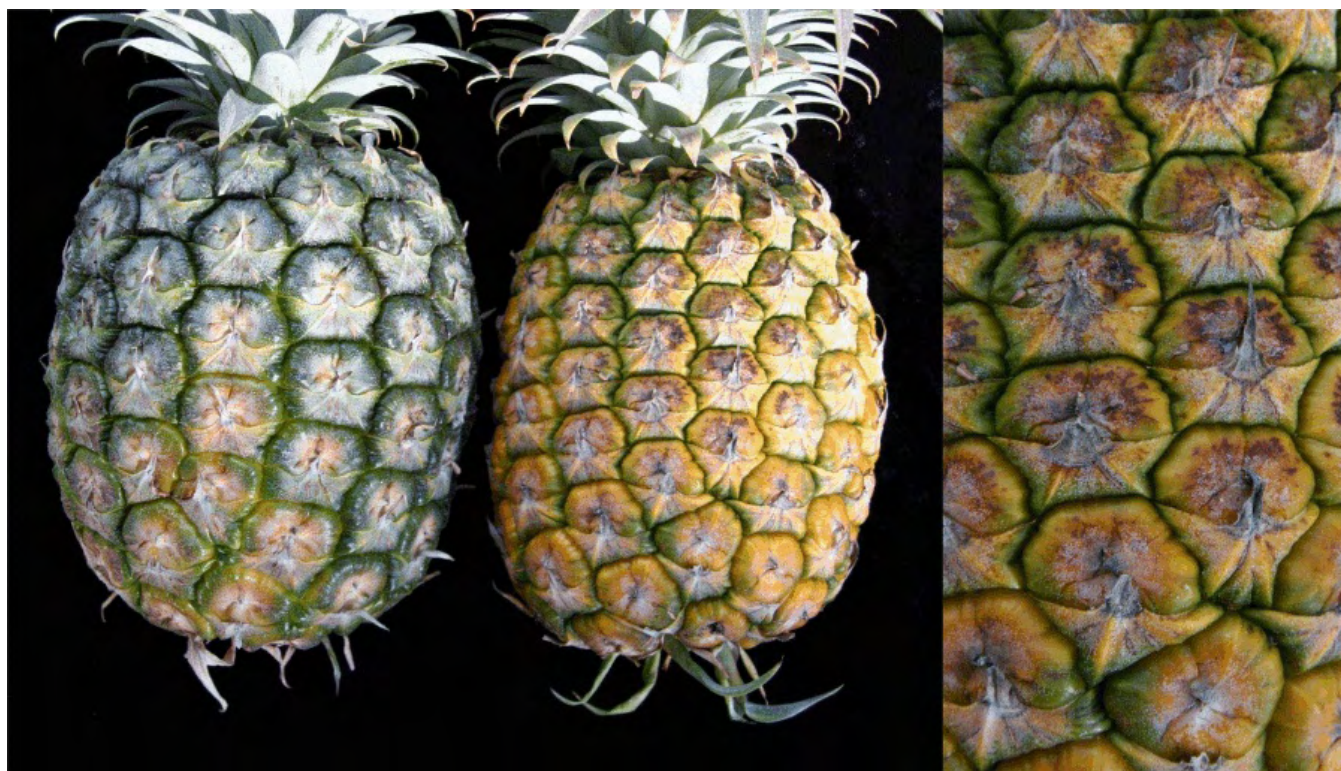


Figure 3. The left photo shows a comparison between an unrusseted fruit that was protected by a paper sleeve (note the large 'eye' size) next to slightly russeted fruit that was not covered. The right photo shows a close-up of a slightly russeted fruit.

**Ed Note:** The russetting described above appears to be similar in appearance to a disorder seen on 'Queen' fruit in South Africa. For details, please see Rabie, E.C., and H.A. Tustin. 2006. Winter Blotching of Queen Pineapple (*Ananas comosus*): a Study on the Occurrence and Possible Cause. Acta Horticulturae 702:191-199.◆

## News From Brazil

### ***New Pineapple Cultivar 'Vitória' is Released***

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At a program held on December 26, 2006, Incaper (Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural) announced that production of the new pineapple cultivar Vitória, which is resistant to Fusariose, one of the most serious diseases in Brazil. It was too late for Dr. Ventura to make more extensive information on the new cultivar available to readers of this issue of Pineapple News. However, he wrote that he plans to provide such information in a future issue of Pineapple News.

The photographs of the plants and fruit of this new cultivar were obtained from a pdf file provided by Dr. Ventura.





Figure 1. Photographs of the new 'Vitória' pineapple hybrid developed at INCAPER.

## **Abacaxi On-Line Available**

Getúlio Augusto Pinto da Cunha, Embrapa/CNPMF,

Abacaxi On-Line, which is edited by Getúlio Augusto Pinto da Cunha is available over the internet. Currently the on-line journal is only in Portuguese at: [http://www.cnpmf.embrapa.br/informativos/abacaxi/abacaxi\\_online\\_v4\\_3\\_06.pdf](http://www.cnpmf.embrapa.br/informativos/abacaxi/abacaxi_online_v4_3_06.pdf). The current issue is Volume 4, Número 3 – Setembro a Dezembro / 2006. Topics in the current issue include:

- Notice and information about the upcoming pineapple symposium in Brazil
- Notice of and details about the newly released fusariose-resistant pineapple cultivar Vitória.
- Embrapa Studies Pineapple in the South Extreme Region of the Bahia
- Technological Information: In vitro Production of Shoots of Ornamental Pineapple
- Fertilization of the Pineapple ' Pearl ' in Coastal Table Lands (Solo De Tabuleiro Costeiro)
- Multivariate Analysis in the Characterization of Pineapple Germoplasm
- Several brief announcements and some links to other Embrapa web sites related to pineapple

Translated with the assistance of <http://babelfish.altavista.com/tr>

## **Progress Report on Pineapple Research in Espírito Santo, Brazil: Pineapple Mealybugs and Related Scale Insect Studies**

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Integrated pest management (IPM) depends on accurate identification of pests and because little is known of the scale insect pests of pineapple in the Brazilian state of Espírito Santo a large part of our recent research has been devoted to identifying the scale insects present in the state. Based on this research we are currently completing two manuscripts that we plan to submit for publication in March 2007 that contain information on scale insects of pineapple in Espírito Santo: "Culik, M.P., Martins, D.S., Ventura J.A. & Peronti, A.B.G., Gullan, P.J., & Kondo, T. New records of scale insects (Hemiptera: Coccoidea) from Espírito Santo, Brazil" and "Culik, M.P., Martins, D.S., Ventura J.A. & Wolff V.R.S. Diaspididae (Hemiptera: Coccoidea) of Espírito Santo, Brazil".

Based on identifications of scale insects from approximately 200 samples (~100 Diaspididae plus ~100 other scale insects) collected from more than 30 species of plants (mostly tropical fruits and ornamentals) throughout the state, these publications document the presence of the following five scale insect species on pineapple in Espírito Santo: *Dysmicoccus brevipes*, *Pseudococcus jackbeardsleyi*, *Diaspis boisduvalii*, *Diaspis bromeliae*, and *Melanaspis smilacis*. And, the planned publications document the presence of a wide variety of other scale insect species (13) that are potential pests of pineapple in this state: *Praelongorthezia praelonga*, *Coccus viridis*, *Dysmicoccus grassii*, *Ferrisia virgata*, *Phenacoccus madeirensis*, *Planococcus citri*, *Planococcus minor*, *Pseudococcus longispinus*, *Pseudococcus viburni*, *Aspidiotus nerii*, *Pinnaspis strachani*, *Pseudaonidia trilobitiformis*, and *Unaspis citri*. Many of these insects are common on other plants in Espírito Santo but we have not observed them on pineapple in our studies (so far). We expect to publish more complete results specifically on our studies of the scale insects of pineapple in the future but some preliminary observations may be of interest and are presented below.

Scale insects were collected from pineapple plants and fruits from ~9 sites (commercial and experimental fields) in 6 municipalities in Espírito Santo (ES) in 2005 and 2006, and from pineapples purchased in Vitória (of probable origin Marataízes,

ES) on ~6 dates from June to April 2006. Preliminary identifications of the insects were made in Vitória and samples of specimens (19 armored scales and 22 mealybugs) were sent to cooperating taxonomists to verify or confirm our identifications.

Of the five scale insect species that we found on pineapple plants in this research (*D. brevipes*, *P. jackbeardsleyi*, *D. boisduvalii*, *D. bromeliae*, and *M. smilacis*), only the mealybug *D. brevipes* is considered to be of economic importance. Mealybugs were relatively common and almost all mealybugs that we have observed on pineapple plants (and fruits) appeared to be *D. brevipes* (having the typical appearance of *D. brevipes*: body oval, pinkish, covered with white powdery wax and surrounded by short wax filaments), and all of the specimens that we examined microscopically were also identified as *D. brevipes*. On a few occasions individual mealybugs that appeared to be different from typical *D. brevipes* (lacking wax or with long thin filaments) were encountered. One of these “non-typical” mealybugs (with little wax and lacking filaments) was subsequently confirmed to be *D. brevipes*. Of the 22 samples of the mealybugs from pineapple examined by taxonomists, 21 were identified as *D. brevipes* and one mealybug collected from the crown of a fruit was identified as *P. jackbeardsleyi*. Thus, our observations indicate that the only species of mealybug common on pineapple here is *D. brevipes* and other mealybug species are not present or are rare on pineapples in this area.

*D. brevipes* was also collected from other plants in Espírito Santo including pumpkin, guava, and coffee. Although *P. jackbeardsleyi* is not common on pineapple here it was found on a variety of other plants including coffee, cassava, and pumpkin. *D. brevipes* was often present in colonies under leaves at the base of the pineapple plants. However, we also observed *D. brevipes* to be relatively common on fruits and in the fruitlets of pineapple fruits. The species was confirmed from pineapple fruits purchased in Vitória on 6 dates from 2005 – 2006, including specimens collected from inside fruitlets and also from fruits collected from the INCAPER experimental farm in Pacotuba. Besides continuing to monitor mealybugs and other scale insects of pineapple in Espírito Santo future efforts will be devoted to identifying the ant species and natural enemies associated with *D. brevipes* and other pests of pineapple here. ♦

## News From Egypt

### ***Pineapple Open Field Trial in Egypt***

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A trial to cultivate pineapple plants in the open field in Egypt has been ongoing for three years. In the first year, pineapple plants derived from tissue culture were successfully produced in large quantity in a small nursery to meet the open field requirements. In the second year, small adapted plants were cultivated in the open field in different areas in Egypt to look for the most suitable climatic conditions. The practical trial resulted in many problems with the climate (frost and moisture deficiency) and soil. Finally, this year one of the four locations provided good results. The best place was in the Ismailia governorate, El-Kassaseen-Agriculture Research Station, Horticulture Research Institute, Agriculture Research Center, Egypt. At this location the climate is more nearly sub-tropical with more ambient moisture than other places and has sandy soil. Vegetative growth is better on sandy soil than on other soil types, with clay soil being particularly poor. Plants were double the size of similar plants grown at the other locations (Figure 1). Pineapple plants at this site were intercropped with maize and fertilized with 15 g/plant of 19-19-19 N-P-K every 2 weeks with a drip irrigation system,.

Intercropping with Maize provided better results than intercropping with banana plants in clay soil (Figure 2). The pineapple leaves in the maize intercrop were wide and long, reaching 50 – 75 cm in length while plants intercropped with banana had smaller leaves. However, the leaves of plants grown under banana were completely green and were protected from the frost during the winter season; the temperature decreased to less than 10 °C in some nights. During the winter, all the plants at all locations suffered frost damage and the leaves turned reddish in color, although some turned white except where the plants were intercropped with banana (discussed in detail in Pineapple News No. 13).

Interestingly, in a trial to avoid the frost threat, pineapple nurseries were located under a low tunnel this winter. This low tunnel, known locally as a 'Keep', was made from natural materials available in the area, which keeps the cost low. A 'Keep' protects the plants from low temperature injury during the coldest nights, conserves moisture and also shades the plants during the day.

On the other hand, cultivating pineapple under maize saved much moisture for the pineapple plants during vegetative growth. Also the plants responded well to chemical fertilization (Figure 3). It was noticed that the small plants (3 – 6 months old) derived from tissue culture and cultivated under shade had better vegetative growth than those directly exposed to the sun. The reason for this is not known, but it may be because of improved water balance. An experiment also is in progress to determine the optimal growth requirements for different kinds of planting materials (slips, crowns, axillary shoots).



Figure 1. Pineapple plants grown under maize in sandy soil; leaf length ranges from 50 - 75 cm.  
 Figure 2. Nine month-old pineapple under banana in clay soil. Plants were protected from frost but growth was slow.  
 Figure 3. Ferti-irrigation treatment, which promoted vegetative growth of pineapple in desert conditions.

Flowering trails were conducted in the Tropical Fruit Department, HRI, to induce plants into flowering. Unfortunately, plants produced a small fruit with big crown. While more than 80 % of the plants produced fruits, others were insensitive to the forcing treatment. Further studies are needed to determine what factors affect forced induction of flowering. Future objectives include getting satisfactory vegetative growth of plants and to determine the best size for forcing. With regard to forcing, the optimum date(s) of forcing must be determined as well. ♦

## News From France

### **CIRAD Pineapple Breeding Program**

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'Smooth Cayenne' x 'Manzana' hybrids were created by the CIRAD pineapple breeding program in the nineties. Some of these hybrids have been released to farmers in the French West Indies. Flhoran 41 and Flhoran 53 proved to have solid fruit qualities for both fresh market and processing. Nevertheless, to meet needs of producers and consumers as well as to conform to new regulations regarding environment preservation and limiting the use of pesticides, pineapple breeding was relaunched at the CIRAD research centre in Martinique in 2004. This new effort will build upon one of the world's largest pineapple genebanks. The general objective is to produce new hybrids for the local and export markets. The specific objectives are to improve the storage behaviour, vigour and tolerance of pineapple hybrids to nematodes through direct hybridisation of Flhoran hybrids.

A large breeding campaign begun in 2004 gave rise to more than twenty thousand hybrid seedlings issued from Flhoran hybrids. The first progenies were placed in the field in the winter of 2004-2005 and are now at the harvest stage. Despite the fact that the hybrids are not expected to express their best qualities in the first cycle, the first results are very encouraging. Most plants are highly vigorous with a strong root system and several among the very first fruits harvested have inherited the good fruit qualities of the parents. These good qualities include size, sugar and acid content, colour and firmness of the flesh, reflecting the good combining abilities of the chosen parental pairs. Selection within the progenies will be continued in 2007 and over the successive crop cycle. The best performing hybrids will be multiplied for further evaluation and selection. Meanwhile, methods for early screening for nematode tolerance and internal browning resistance will be developed.

In collaboration with the Institut de recherche pour le développement (IRD), an original method has been developed to test the plant behaviour versus nematodes. Pineapple plants are grown in tubs filled with soil infested with nematodes (test) or without nematodes (control) for six months in the greenhouse. Roots and plant development and nematode infection are measured during



and at the end of the assay. Tests conducted on varieties known to be susceptible or tolerant to nematodes proved the reliability of the method. We will search for nematode-tolerant hybrids among the ones selected for their general agronomic performance and fruit qualities using this newly developed method.

Ongoing research also aims at understanding the mechanisms leading to post-harvest internal browning (IB) induced by cold during fruit storage. The induction of polyphenoloxidase activities in response to cold storage is measured within leaves and fruits and correlations are searched for. A specific objective is to identify molecular probes for susceptibility to IB that could be used as an early selection tool within hybrid progenies.

## ***CIRAD Pineapple Genebank Database Online***

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As a result of years of collection and germplasm exchange, and of an EU-funded project in which institutions from Brazil, France and Venezuela collaborated, CIRAD has gathered hundreds of pineapple cultivars and species of the genus *Ananas* and a wide collection of over 600 accessions has been established in Martinique, FWI, at the CIRAD research centre. This collection includes a wide range of genotypes from many geographic origins, and is presently the most diverse in existence. All accessions in the genebank have been evaluated using common methods for the characterization and evaluation of pineapple germplasm. As a tool to promote information exchange and germplasm utilisation, CIRAD developed a database built on a standardised format. However, the database and its valuable information were not easily accessible to anyone. The development of a joint CIRAD-INRA (Institut National de la Recherche Agronomique) project to build a Tropical Plants Biological Resources Centre (CRB) of the French West Indies made it possible to develop a web portal and give open access to the database directly on the internet. This website makes it possible to get information on cultivated plants conserved by CIRAD and INRA in Guadeloupe and Martinique: sugarcane, bananas, yam, perennial fruit crops, flowers and pineapple. Eventually, the portal will be trilingual: French, English and Spanish. The Tropical Plants Biological Resources Centre of the French West Indies portal is currently accessible though not all features have been implemented. Access to the portal is at <http://collections.antilles.inra.fr/BRCPortal/initHome.do>.

## ***Ethephon on Pineapple: News About Uses and Regulation***

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### **Introduction**

The use of ethephon in pineapple was proposed in the 1970s by CIRAD agronomists in Martinique and Côte d'Ivoire to reduce the time between the harvest of early ripe fruits and the harvest of the late ripe fruits in a pineapple field and to get a more homogeneous external colour of the fruits (Audinay, 1970; Poignant, 1971). Ethephon does not actually colour the fruit, it rather degreens the shell of the fruit by destruction of chlorophyll. The closer the fruit is to natural ripening, the more efficient is the degreening. If correctly applied at the right time, ethephon treatment does not reduce significantly the internal quality of the fruit. This technique drastically changed the management of the harvest because formerly the desired tonnage was harvested from many fields whereas with ethephon degreening the same tonnage could be obtained from only few fields. Few drawbacks to ethephon degreening have been identified as long as the application follows the recommendations (2 – 3 L ha<sup>-1</sup> when ~1% of fruits begin to colour naturally). One drawback is that sometimes fruits are relatively insensitive to the treatment, for example when high levels of nitrogen have been applied during vegetative growth. This has generally a consequence, the farmer applies higher doses of ethephon, earlier (as many as 3 to 4 weeks before natural ripening sometimes). The result is fruit with poor quality, with a shorter shelf life, withered crowns after cold storage and fruit more sensitive to Internal Browning. With the development of new varieties and also the general evolution of customer sensitivity to the use of pesticides in agriculture, one could expect some changes in the use of ethephon.



### **Ethephon, degreening in new varieties and other uses**

**Degreening of the fruits:** The hybrids MD2, which is produced on a large scale in many countries and Flhoran 41, the red hybrid from CIRAD, showing the same behavior after ethephon application. These hybrids both have a shorter interval from Forcing to Harvest than does 'Smooth Cayenne' (about one week), they naturally degreen faster and the gradient of colour between the bottom and top of the fruit is very small. We realized that a lower dose of ethephon can be applied to the fruit of these two varieties ( $1.0 \text{ L ha}^{-1}$  on 60 000 fruits) to get the correct colour : yellow for the MD2 and red for the Flhoran 41. The red colour is clearly enhanced by ethephon treatment through its promotion of anthocyanin biosynthesis. One of the beneficial effects of the treatment on MD2 is that it reduces the risk of over ripening of the fruit as this variety is very susceptible to this problem. On a practical basis, we also noticed that growers use the same dose they are used to with 'Smooth Cayenne'.

**Reduction of peduncle length:** One of the characteristics of MD2 is its short peduncle. The fruits are "deep" inside the plant and better protected from sun burn and lodging. We did experiments on Flhoran 41 to reduce the peduncle length with ethephon application in the heart of the plant 3 to 4 weeks after forcing. We found that the peduncle is shortened (5 to 10 cm depending on the dose and time of application) without any negative effects on fruit quality. The best dose/time application seems to be 3 to  $4.0 \text{ L ha}^{-1}$  of ethephon applied 3 weeks after forcing in our condition in Martinique. Adjustments are probably needed in different production areas and for other varieties.

**Forcing:** Ethephon is commonly used for forcing in many production areas where the day-night temperature difference is high enough to naturally increase the sensitivity of pineapple to forcing. Recent experiments in Guadeloupe showed that late applications of ethephon in the afternoon not only increased the percentage of forced plants (91% for a late afternoon application vs 30% for application around mid-day) but also increased the number of fruitlets/fruit, leading to a 20% increase in yield. Higher doses also induced a significant reduction of peduncle length (20%).

### **Ethephon as a residue in fruit and new regulations on pesticides uses**

European regulations on the use of pesticides are becoming more and more detailed and strict. A lot of phytosanitary products used on pineapple have been banned for pineapple production on European territories, and Maximal Residue Levels (LMR) established for production imported into Europe. For ethephon on pineapple the LMR is  $2 \text{ mg kg}^{-1}$ , which is also the limit adopted by the Codex Alimentarius. One can expect in the near future that the LMR will be fixed at detection level which means a level far below the current one and probably, at last, ethephon will be banned. Previous experimentations during the 80s in Côte d'Ivoire (Soler, 1992) showed that most of the ethephon applied remains as a dry residue at the surface of the skin. Only 20% to 40%, depending on the external temperature, actually penetrates inside the fruit, but the experiments showed also that the dry residue on the skin may be re-dissolved by dew or light rains leading to further penetration of ethephon inside the fruits. Ethephon is then transformed into ethylene and after 12 days (fruits left on the plant in the field) only 5% could be detected inside the fruit. More recent experiments have been conducted especially regarding the residue levels vs the local practices (ethephon applications of 3, 6 and  $9 \text{ L ha}^{-1}$  on 55 000 fruits) during years 2001-2002 (Teisson, 2001; Bourgeois, 2002). The results confirm that a low dose of ethephon does not significantly reduce fruit quality and also shows that residue levels are below the authorized limit. Meanwhile higher doses reduce Brix levels (1 to 2 %), increase acidity level ( $1 \text{ meq } 100\text{ml}^{-1}$ ) and lead to residue levels as high as four times the authorized limit. In la Réunion island where the 'Queen' cultivar is grown, ethephon is also used for degreening. As the production is in a European territory, they pay particular attention to residue problems. Producers not only need to reduce the dose to a minimum level, they also have established a minimum time before harvest of 2 weeks for the treatment (Joas, 2006).

### **Conclusion**

Ethephon is still a very useful "tool" for pineapple farmers, but as far as fruit degreening is concerned, this chemical is expected to be banned soon. New varieties such as MD2 and Flhoran 41 that do not need the chemical to get their colour represent definitively a strong commercial advantage for the producers. At this stage it is difficult to imagine what will be the regulation about the use of ethephon for forcing or to reduce peduncle length. The applications in these treatments are made long before harvest and no residue problem should be expected from them. Nevertheless it is not impossible that a ban of the chemical for degreening would also mean a ban for any uses on pineapple.

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## **Growth Characteristics of the Pineapple Cultivars 'MD2' and 'Flhoran 41' Compared With 'Smooth Cayenne'**

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### **Introduction**

New pineapple varieties are now well established in the markets and this "segmentation" will increase in the near future to offer consumers a real choice of differentiated products such as already exists for other fruits. At the growers level, different pineapple cultivars also means a need to adapt the cultural practices due to different behaviours of the cultivars in terms of growth, nutrient requirements and sensitivity to biotic and abiotic stresses. Examples of this diversified behaviour include:

- Ethephon dose for degreening may be lower for 'MD2', 'Flhoran 41' and 'Queen' than for 'Smooth Cayenne'
- 'MD2' is sensitive to phytophthora and to over-ripening but insensitive to Internal Browning
- 'Flhoran 41' is sensitive to soil-borne parasitism but shows exceptional quality characteristics for fresh market as well as for processing and does not need ethephon for degreening.
- 'Queen' shows very good fruit quality with a high level ascorbic acid but is very sensitive to Wilt and Internal Browning.

In addition, each variety has some unique growth characteristics.

### **Growth characteristics : plant weight, D leaves and number of leaves**

We measured a few growth characteristics of 'MD2', 'Flhoran 41' and 'Smooth Cayenne', between planting and forcing. Classical planting material was used, in this case 400 g suckers, which are less susceptible to natural flower induction than bigger suckers (PY, 1960; Lacoëuilhe, 1975). The suckers were planted at a density of 55 000 plants/ha in Côte d'Ivoire during May 2005, a hot and humid period. The maximum temperatures ranged between 26.7 to 33.5°C with rainfall of 1700mm during the 10 months of the experimentation. Because the period of the experiment was very wet the plants were not irrigated.

Plant weights were similar for the three cultivars and the speed of growth also was similar. Exportable fruits, average weight 1.5kg, are obtained with 2.5 kg plants. This weight was reached, on average, after 240 days for 'Flhoran 41', 242 days for 'MD2' and 252 days for 'Smooth Cayenne'.

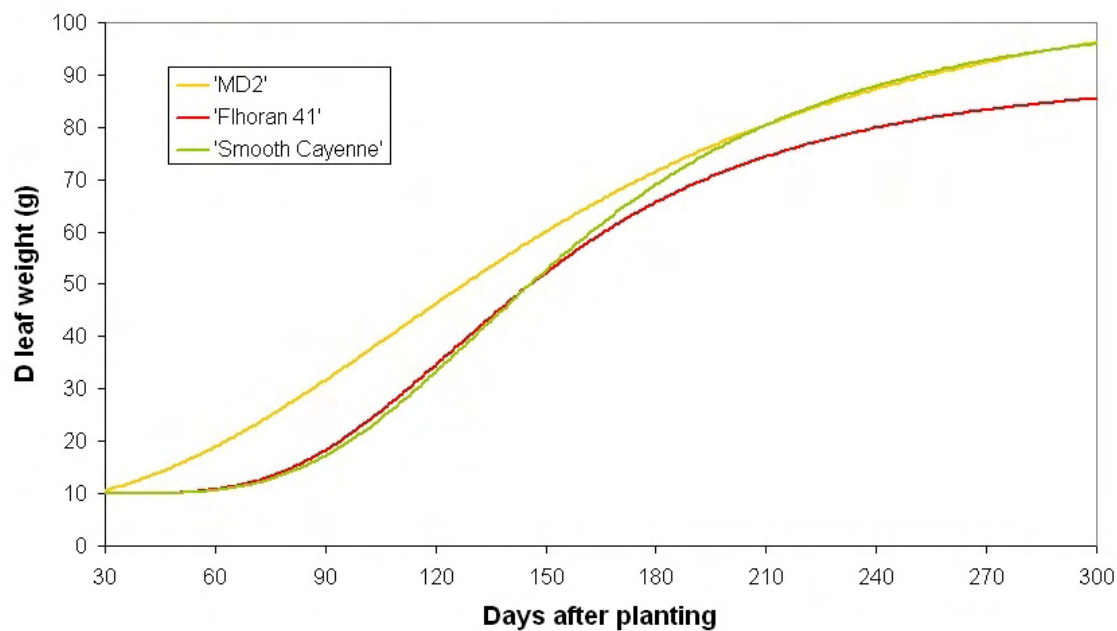
The increase in weight of the D leaves (as defined by Py *et al*, 1984) of the three cultivars shows the same pattern and follows the classical sigmoid growth curve observed for pineapple (Lacoëuilhe, 1976; Py, 1973) (Figure 1). 'MD2' D leaves had a greater weight than those of the other cultivars, about 10 g up to four-five months after planting. Then gradually the weight of 'Smooth Cayenne' D leaves increased until they were similar in weight to those of 'MD2' plants. The weight of 'Flhoran 41' D leaves follows the same pattern as did those for 'Smooth Cayenne' plants from planting to the 5th month but at the end averaged 10 g less than those of the two other cultivars.

'Flhoran 41' consistently had a higher number of leaves than did 'Smooth Cayenne', which had a higher number of leaves than did 'MD2'. Leaf numbers at 16 weeks after planting were 41 for 'Flhoran 41', 36 for 'Smooth Cayenne' and 30 for 'MD2' (Figure 2). At the time of forcing leaf numbers were 62 for 'Flhoran 41', 55 for 'Smooth Cayenne' and 50 for 'MD' (Figure 2).

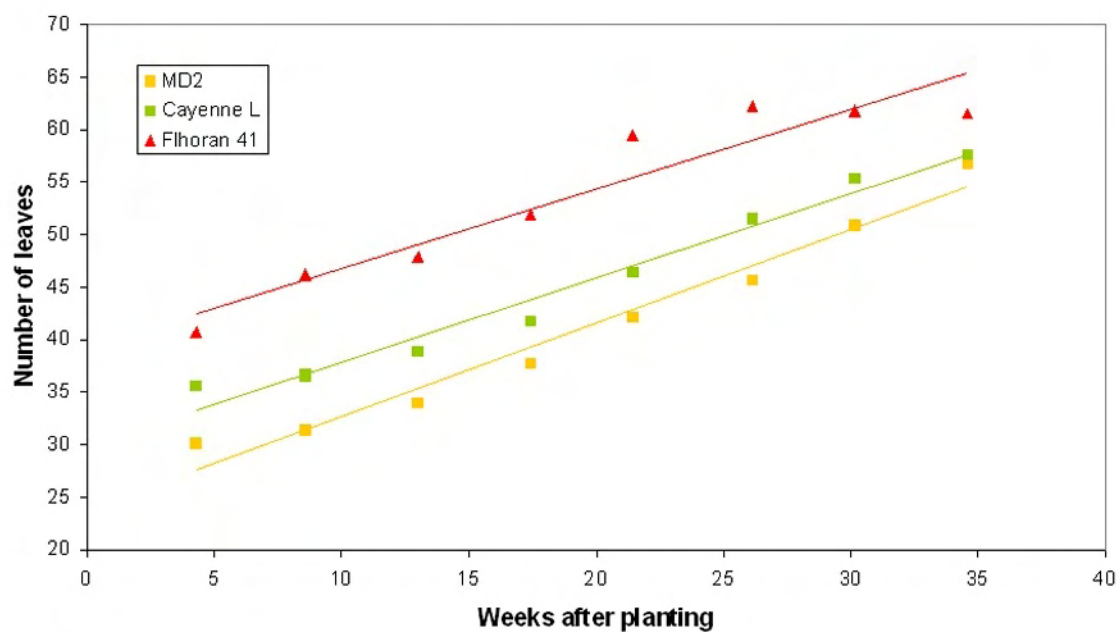
Clearly 'Flhoran 41' has more but smaller leaves than either 'Smooth Cayenne' or 'MD2'. Since the weights of all plants were similar, under good growth conditions 'Flhoran 41' compensates for having smaller leaves by having more of them. Finally, we confirmed that the classical correlation between D leaf weight and plant weight holds for these new cultivars.

We also observed the same behaviour on the same cultivars in greenhouse experiments in Martinique, (plants in pots, experiments still underway). The impact of nematodes on the three cultivars was evaluated by multiplying *Rotylenchulus reniformis* on *Phaseolus vulgaris* and then inoculating half the pots with this nematode during a 2-month growth period. Meanwhile the other half of the pots were freed from nematodes by a 2-month immersion of the soil before planting. The reduction of foliar emission due to nematodes was 10% on 'Flhoran 41' vs 2% for 'Smooth Cayenne' and 6% for 'MD2'. The D leaf weight was reduced by 62% and 59%, respectively, for the nematode sensitive 'Flhoran 41' and 'Smooth Cayenne' cultivars but was reduced only by 29% on 'MD2', which is more tolerant to *Rotylenchulus reniformis*.

**Figure 1. D leaf weight for cultivars 'MD2', 'Flhoran 41' and 'Smooth Cayenne'**



**Figure 2. Leaf numbers for 'MD2', 'Flhoran 41' and 'Smooth Cayenne' grown from 400g suckers.**



## Conclusion

The data for D leaf growth for the 3 varieties provides a good example of how careful growers must be with new varieties. D leaf weight is often used as an indicator of forcing time in pineapple, but it should be used with care. In 'Flhoran 41', a D leaf weight of 70 g is sufficient to get exportable fruits, whereas 80 g is the standard for 'MD2' and 'Smooth Cayenne'. As a matter of fact, we realized that on farms growing 'Flhoran 41', it was not easy to obtain a D-leaf weight of 80 g in Côte d'Ivoire conditions. Even more, it was unnecessary and sometimes led to the forcing of plants that had reduced growth rates, which resulted in plants yielding smaller fruits with fewer fruitlets/fruit as demonstrated by Lacoëuilhe (1975). Such other factors as susceptibility to nematodes can affect growth and yield and make it more difficult for growers to adapt themselves to new varieties.

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## News From South Africa

### ***Pineapple Farmers' Day***

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A pineapple Farmers' Day was held on 9<sup>th</sup> November, 2006 at Summerhill Farm, Bathurst – the research farm of the partnership between the Agricultural Research Council's Institute for Tropical and Subtropical Crops and the Pineapple Growers Association. The 102 guests were welcomed by Dr. O. Van Rensburg, ITSC Director, followed by an Opening Address by Philip Clayton, Chief Risk Analyst of the Standard Bank of South Africa Limited. Entertaining and informative lectures were then given by a number of speakers, including:

- Graham Petty, Researcher, ARC-ITSC, Bathurst. "Effect of Telone® dosage levels on pineapples growing on clay-loam or sandy-loam soils."
- Nico Smit, Manager Sap Diagnostic Services, Omnia Nutriology. "Progress: Pineapple Sap Analysis."
- Elmarie Rabie, Researcher, ARC-ITSC, Hluhluwe. "Zululand Pineapple Research."
- Heather Raymond, Technical Manager, Phosyn/Yara South Africa. "Trace Elements in Pineapple."
- Matthew Lester, Associate Professor – Taxation, Rhodes University. "The Economic Conditions Facing Farmers."

A summary of one of these lectures is given below.

### ***Evaluation of dosage levels of Telone II® (1,3 dichloropropene, 1110 g L<sup>-1</sup>) for control of Root-knot nematode, Meloidogyne spp, on Clay-loam, and Sandy-loam Soils***

Graham Petty, at Bathurst Farmers' Day.

## Summary

Options, in the fight against pineapple nematodes, are very limited and becoming increasingly limited, and the South African pineapple industry has opted for the preplant use of the soil fumigant 1,3 dichloropropene (1110 g L<sup>-1</sup>) (Telone®) at the registered rate of 100 L ha<sup>-1</sup>. Visiting growers from overseas countries have expressed their reservations about the adequacy of this rate; however, due to the cost factor our growers have been reluctant to apply the product at higher rates. In an effort to resolve the dilemma and ascertain if the cost-benefit of higher rates would justify increasing dosage rates, a study was undertaken in the Bathurst district of Eastern Cape, South Africa, on effect of different Telone® rates on (a) Root-knot nematode infestation and damage, (b) plant growth, (c) fruit yields and gradings, and (d) nett increase in profitability.

Telone® was applied as preplant soil injection at rates in L ha<sup>-1</sup> of 0, 100, 125, 150, 200 and 300, followed after 1 week by planting of 'Smooth Cayenne' tops/crowns. At 12 and 18 months after applying Telone®, assessments were made of the above



mentioned variables. Two trials were established on clay-loam soil types and two on sandy-loam soil types and from the data means for these two soil types the following conclusions were drawn.

<b>Clay-loam</b>	<b>Sandy-loam</b>
<b>a) Infestation of pineapple roots with R-K nematode</b>	
At 12 months, the 100 L ha <sup>-1</sup> rate was less effective than the higher Telone® rates which all showed nearly complete nematode absence. At 18 months, there was little difference between Telone® rates.	At 12 months, the 100 L ha <sup>-1</sup> rate showed slightly more nematodes in roots than higher Telone® rates.  At 18 months, 100 L ha <sup>-1</sup> showed far more nematodes than all higher rates.
<b>b) Degree of root damage based on a Root Galling Index</b>	
At both assessment times there was a dosage response i.e. more Telone® = less root damage. The amount of damage increased from 12 months to 18 months, but levels of damage were low in all treatments.	At both assessments, Untreated Control showed severe root damage. There was a general dosage response to Telone®, with 100 L ha <sup>-1</sup> markedly worse than higher rates. At 12 months, 150 L ha <sup>-1</sup> showed nil damage, and very little at 18 months.
<b>c) Infestation of pineapple root zone soil with R-K nematode</b>	
At 12 months, 100 L ha <sup>-1</sup> Telone® was somewhat less effective than the higher rates, which gave perfect to almost perfect control. At 18 months, there was a clear dosage response up to 200 L ha <sup>-1</sup> , i.e. more Telone® = less soil infestation.	At 12 months a dosage response trend up to 150 L ha <sup>-1</sup> was apparent. At 18 months there was a very clear dosage response up to 300 L ha <sup>-1</sup> , with poor nematode reduction at 100 L ha <sup>-1</sup> and good reduction at 150 L ha <sup>-1</sup> and more.
<b>d) Plant growth/increase in plant mass</b>	
The 100 L ha <sup>-1</sup> rate did not show any increase in plant mass. Telone® rates from 125 L ha <sup>-1</sup> to 200 L ha <sup>-1</sup> gave a 4% average increase.	A dosage response was again apparent with the 12 and 18 month trends being very similar. The growth response at 150 L ha <sup>-1</sup> , and more, was considerably greater than that for lower Telone® rates, giving at least 60% better growth.
<b>e) Increase in canning grade fruit yield</b>	
Increased yield varied from 3% to 5.6 %, the greatest increase being for 125 L ha <sup>-1</sup> .	Increased yield varied from 54% to 66%, with a tendency for greatest yields from 150 L ha <sup>-1</sup> and more. The general trend in yield response followed that seen in plant growth response to different Telone® rates.
<b>f) Increase/decrease in nett value of pineapple fruits</b>	
Apart from the 125 L ha <sup>-1</sup> rate, an inverse response was obtained to profitability with increasing levels of Telone®, i.e. more Telone® = less profit, due to the greater cost of increasing Telone® volumes. At 125 L ha <sup>-1</sup> , nett value increased 0.5%. Higher rates decreased profitability of the plant crop.	There was a somewhat inverse response to profitability, compared to increased canning grade fruit yield, with increased Telone® above 100 L ha <sup>-1</sup> , especially at 300 L ha <sup>-1</sup> , due to the increasing cost of greater volumes of Telone®. Profitability decreased from 82.5% (100 L) to 80% (200 L) relative to that for the Untreated Control.

All the above findings refer to the plant crop. Effect of Telone® levels on fruit yield and profitability for the ratoon crop are yet to be determined. It is anticipated that, due to the greater impact of root-knot nematode on ratoons there will be a greater response to the higher Telone® levels by the ratoon crop than was observed in the plant crop. The Telone® cost is a once-off cost and the benefit is the combined yield increase of plant plus ratoon crops.◆

## News From Thailand

### ***F<sub>1</sub> Hybrids and Genetic Characters of Pineapple***

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During 1992 to 1997, a Pineapple Selection and Breeding Program was conducted at the Faculty of Agriculture, Rajamangala University of Technology Srivijaya, Nakhon Si Thammarat, Thailand. Direct and reciprocal crosses were made using 'Queen' (Phuket clone) and 'Smooth Cayenne' (Pattavia clone) cultivars and both cultivars were also selfed. The objectives of this research were to produce F<sub>1</sub> hybrids between 'Queen' and 'Smooth Cayenne' clones, to study the heredity of leaf characteristics, and finally, to select F<sub>1</sub> hybrids that have a good characters. The result, 296 F<sub>1</sub> hybrids from direct crosses ('Queen' x 'Smooth Cayenne') and 131 F<sub>1</sub> hybrids from reciprocal crosses ('Smooth Cayenne' x 'Queen') were produced. However, the cultivars can not be selfed because they are self-incompatible. Ten F<sub>1</sub> hybrids selected from the progeny were identified as HQC34, HQC36, HQC66, HQC324, HQC421, HQC426, HQC827, RC132, RC216 and RC319.

In 2001, the selected F<sub>1</sub> hybrids were planted in field plots and evaluated for yield and agronomic characters such as °Brix, heart rot resistance, fruit weight and crispness. The F<sub>1</sub> hybrids HQC34 and RC212 were selected for further evaluation. Hybrid HQC34 gave high yield and had good agronomic characters and has been propagated *in vitro*. An on-farm trial will be done in the next late rainy season.

For genetic characters of the F<sub>1</sub> hybrids, the observed plant numbers expressing spiny and piping characteristics were 162:134 for direct and 71:60 for reciprocal crosses. These ratios were non-significant by the chi-square test based on a 1:1 hypothesis. Thus it was confirmed that there is one pair of genes having 2 alleles, S and s, with genotype ss producing the spiny phenotype and genotype Ss producing the piping phenotype. These genetic characters will be used in pineapple breeding in the future.

### ***Inheritance of Transgene of Genetically Modified Pineapple***

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#### **Background**

Genetically modified pineapple plants incorporating Basta™ herbicide resistance were established in 2001. These transgenic pineapple plants were evaluated for transgene (bialaphos resistant gene: *bar* gene) stability and expression under field conditions during 2003-2005. The stability and expression of *bar* gene showed positive results in tissue cultural-derived transgenic clones evaluated using molecular techniques and were resistant to Basta™ herbicide when sprayed with this herbicide whereas untransformed plants of the Phuket clone were killed by the herbicide.

#### **Recent Research**

Inheritance of the transgene was studied by hybridization between transgenic and non-transgenic pineapple cultivars 'Smooth Cayenne' and 'Queen'. Direct and reciprocal crosses as well as selfs were made using Transgenic pineapple (TP) and non-GM pineapple clones such as Pattavia (PV) and Phuket (PK). The seven crosses were TP x PV, TP x PK, PV x TP, PK x TP, PV self, PK self, and TP self.

#### **Preliminary Results**

Seeds and plantlets from direct and reciprocal crosses of TP and PV were obtained but all self and both direct and reciprocal crosses between TP and PK did not give any seed. GUS expression was used for checking for the presence of the transgene (*bar* gene) in leaves of plantlets from hybridization. Out of 125 plantlets obtained from the PV and TP crosses, 71 showed positive GUS expression and 54 were negative for the gene. Differences in numbers of plants showing GUS expression were not significantly different by Chi-square analysis. Plants resistant and sensitive to Basta™ herbicide therefore showed a 1:1 ratio, which follows Mendel's Law of inheritance for a pair of genes controlling the trait.

#### **Future Work**

These F<sub>1</sub> generation plants grown in the pots will be sprayed with Basta™ herbicide for evaluation of herbicide resistance when the plants are 8 months old. The ratio of Basta™ herbicide resistant and non-herbicide resistant pineapple plants will be evaluated regarding their conformance to Mendel's Law. ♦

## News From the United States (Hawaii)

### ***First Report of Bacterial Heart Rot of Pineapple in Hawaii***

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#### **Background**

Due to the increased popularity of low-acid pineapple hybrids in the fresh fruit market, some Hawaiian plantations began importing planting stocks in the 1990s to speed the replacement of less desirable cultivars in order to remain competitive. Importation of either tissue-cultured hybrid stocks or shoots (suckers) harvested from mature plants was seen as the most logical solution to meet consumer demand, as it would have taken up to 10 years to harvest fruit if planting materials were multiplied solely from the existing Hawaii stock plants.

In 2003, a suspected bacterial heart rot outbreak caused by *Erwinia chrysanthemi* was discovered in a Hawaii pineapple field planted with suckers that had been imported from Costa Rica and Honduras. Although the pathogen was known to exist in the state, it had never previously been reported on Hawaiian pineapple. The outbreak coincided with the importation and large-scale planting of a low-acid pineapple hybrid, suggesting that either the particular strains of the pathogen causing the disease in pineapple were newly introduced on latently-infected planting stock or that local endemic strains of *E. chrysanthemi* had caused heart rot on the new low-acid cultivar, which is more susceptible to heart rot disease than 'Smooth Cayenne'. As the former scenario would involve regulatory action by both the state and federal government, a collaborative effort between the affected pineapple company, the Hawaii Department of Agriculture and the University of Hawaii was undertaken to compare local strains of the pathogen with those found in the infected plants in an effort to determine the most probable origin of the disease outbreak.

#### **The disease**

Bacterial heart rot (also called bacterial fruit rot or bacterial heart and fruit rot) has been reported in pineapple-growing regions of Asia and Central America (Rohrbach and Johnson, 2003). Symptoms (Figure 1) typically begin as water-soaked lesions on leaves surrounding the apical meristem and progress to characteristic "blisters" (gas-filled brown streaks on the lamina of the leaf) that help differentiate it from rot caused by other bacteria and fungi. A few days after initial infection of the meristem and apical and lateral buds, the pineapple heart and stem can be easily detached from the below-ground portion of the plant.

Exudate from collapsed infected fruits and leaves are the most likely source of inoculum for secondary spread to healthy plants where infection occurs through stomata or wounds. The bacteria also can be transmitted by wind, rain, and insects such as ants, pineapple souring beetles, and vinegar flies. Young plants (4 - 8 months old) are most susceptible to infection, and crown- or sucker-initiated plants are more susceptible than the ratoon crop (Lim, 1985). Under optimal environmental and cultural conditions, complete collapse of the plant may occur 1 - 2 weeks after the initial infection.

#### **Results and ongoing work**

Of particular concern during the initial stages of the investigation was the rapid differentiation of the bacterial heart rot pathogen *E. chrysanthemi* from the closely-related and ubiquitous *E. carotovora* due to the regulatory potential of the former species. Although both cause water-soaked lesions and rot on pineapple crowns and leaves, symptoms caused by *E. carotovora* manifest immediately whereas *E. chrysanthemi* can form latent, nearly undetectable infections in planting stock that can lead to major epidemics in areas not previously affected by disease. Using a panel of bacteriological tests (including pectolytic enzyme activity and indigoidine pigment production) along with 16S rDNA sequence analysis, *E. chrysanthemi* was identified from field plants originating from the Costa Rican and Honduran stock materials. On the other hand, only the non-regulated *E. carotovora* was isolated from the few symptomatic suckers found among the planting stocks imported from the Philippines. Further importations from Central America were prohibited whereas importation from the Philippines was allowed to continue. Pineapple leaf inoculations revealed that only *E. chrysanthemi* strains isolated from symptomatic pineapple plants produced water-soaked lesions similar to those observed on the original plants. Thus, it was confirmed that these particular strains were the causal agents of the Hawaiian bacterial heart rot outbreak. Rep-PCR fingerprint analysis using the BOXA1R primer differentiated the pineapple-isolated *E. chrysanthemi* from those obtained from other plants and irrigation water in Hawaii and indicated that the pathogen population infecting pineapple was not one previously isolated in the state. However, due to the limited number of reference strains available in Hawaii, the pineapple-associated strains were not irrefutably identified as foreign imports. Current expansion of the *E. chrysanthemi* culture collection and genetic comparisons between local and imported strains should allow a final determination to be made.



Figure 1. Symptoms of bacterial leaf and heat rot of PRI hybrid 73-114.

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## An Update on Pineapple Root Rot Diseases

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### Pathogenicity of *Phytophthora palmivora*

A study was conducted to determine if *Phytophthora palmivora* is pathogenic on pineapple roots. This question has arisen on a few occasions and has been mentioned in some older references on the subject of organisms causing root rot of pineapple. The following data were obtained from a single trial replicated three times with rooted crowns of the pineapple hybrid 73-114 (MD-2). The hybrid is known to be highly susceptible to root and heart rotting organisms. Crowns of pineapple hybrid 73-114 were rooted in water in plastic drinking cups. When the roots were at least 2.5 cm long, the cups were inoculated with four 1 cm<sup>2</sup> pieces of V-8 agar containing none (Control) or one of the three *Phytophthora* pathogens. The inoculated plants were incubated at 22-23 °C for 3 weeks and data were collected on percentage of infected roots (Table 1).

Table 1. Percentage root infection after 3 weeks of incubation with 3 strains of *Phytophthora*.

Fungal species	Infection, %
<i>Phytophthora cinnamomi</i>	42%
<i>Phytophthora nicotiana</i>	100%
<i>Phytophthora palmivora</i>	28%
Control	0

Based on the above data, it is concluded that *P. Palmivora* is able to infect roots of the susceptible pineapple hybrid 73-114 but the fungus was not as virulent a pathogen as *P. cinnamomi* or *P. nicotiana*. Incubation took place at 22-23 °C, a temperature closer to the optimum for *P. Nicotiana* than for *P. cinnamomi*, which it is assumed accounts for the higher infection percentage associated with *P. Nicotiana*. With respect to *P. palmivora*, it appears that it is either a poor pathogen on 73-114 or the incubation



temperature was above the optimum for this species. The pathogenicity of *P. palmivora* on 'Smooth Cayenne', which is more resistant to *Phytophthora* than is 73-114, apparently remains to be determined.

#### ***Phytophthora* resistance to Aliette®**

In 2001 Australian researchers Graham and Marcel Sterling found strains of *Phytophthora cinnamomi* to be resistant to the fungicide Aliette®. Aliette® has been exclusively used for control of *Phytophthora nicotiana* and *P. cinnamomi* in Hawaii and world wide for more than 30 years. Aliette® is used in Hawaii as a pre-plant seed dip and periodic foliar sprays are also applied. In recent years, many growers have been switching to a phosphonate derivative such as Phosguard® or Fosject-200®. Phosphite has been determined to be the breakdown product of Aliette® that is responsible for control and prevention of *Phytophthora* infections.

Over the past several years in Hawaii, *Phytophthora* infections have become more difficult to control with post-plant applications of Aliette®. In a preliminary study, areas prone to *Phytophthora* rot were surveyed and a number of *P. cinnamomi* strains were collected and bio-assayed for resistance to Aliette®. The study method involved culturing of the strains of *Phytophthora* on 1% V-8 agar media to which Aliette was incorporated at levels of 3, 10, 30, 100 ppm. A 5mm inoculum plug was placed in the center of the plate and the plates were incubated at room temperatures, approximately 20 °C, for 10 days. At the end of the incubation period, mean radial growth was measured.

The results of this study indicated clearly that some degree of resistance to Aliette® is present in Hawaii's *P. cinnamomi* strains. However, the test is not considered definitive because the control strain of *P. cinnamomi*, which was collected from a pineapple field six years before the test was conducted, also grew on media containing Aliette® at all levels (Table 2). Future bio-assay studies will depend on finding *P. cinnamomi* strains that were not subjected to Aliette® over a period of time.

Table 2. Mean mycelia radial growth (mm) after 10 days.

Isolate	Aliette concentration, mg L <sup>-1</sup>				
	3	10	30	100	control
113-1		33	40	38	18.7
	37				
112		42	37.7	26.7	14.3
	25				
110-1		27	30	25.7	12
	27.7				
109-1		29.3	29.3	25.7	12
	27.7				
Control	47.3	44	33	7	43

### ***Pineapple Mealybug Wilt-associated Viruses and Pineapple Badnaviruses: Diversity and Distribution in Commercial Pineapple Hybrids and Various Pineapple Accessions in Hawaii.***

Cristita Verna Q. Subere\*, D.M. Sether, F.T.P. Zee & J.S. Hu. Department of Plant and Environmental Protection Sciences.

Pineapple is an important agricultural commodity in the state of Hawaii. There is a need to study the diversity, distribution, and incidence of plant viruses infecting newly imported pineapple hybrids and pineapple accessions to develop appropriate control strategies. Field surveys conducted on two commercial pineapple hybrids and 131 pineapple accessions maintained at the USDA-ARS National Clonal Germplasm Repository (NCGR) in Hawaii showed the presence of pineapple mealybug wilt associated ampeloviruses (PMWaV) (Family *Closteroviridae*) and putative badnaviruses (Family *Caulimoviridae*). Detection of PMWaV and badnavirus infections were accomplished using reverse transcriptionpolymerase chain reaction assays (RT-PCR) or polymerase chain reaction assays (PCR), respectively. Screening results for two commercial pineapple hybrids showed the occurrence of single and mixed PMWaV infections. One hybrid, plants of which were imported from Costa Rica and Philippines, showed higher PMWaV incidences in the planting materials derived from Costa Rica. Among the two hybrids, PMWaV1 incidence (37%) was highest in one hybrid whereas PMWaV3 incidence (69%) was highest in the other. PCR assays conducted on the same hybrids showed a putative badnaviruslike sequence designated as B was most common in one hybrid while dual infections of putative badnaviruslike sequences A and B were present in the other hybrid. Of the 131 pineapple accessions screened for PMWaV infections, PMWaV2 was commonly found in 15% of the accessions as a single infection and in 38% of the accessions as a mixed infection. Badnavirus-like sequence B was found in all of the accessions tested. In conclusion, screening of pineapple hybrids and pineapple accessions has reconfirmed published results that there are currently at least three distinct PMWaV's. In

addition, four putative badnavirus-like groups (A, B, C, and M) are present in Hawaii. Information derived from this study will be important for the development of control strategies to reduce or eliminate spread of PMWaVs and badnaviruses.

## ***Update on Pineapple Production in Hawaii***

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### **Del Monte Fresh Produce Hawaii, Inc. Closes After 100 Years in Hawaii**

In February 2006 Del Monte Fresh Produce Hawaii Inc. announced the company's intent to close its Hawaii plantation by December 2008. Management announced that harvesting, packing and shipping of fresh fruit to the U.S. mainland would continue during this period. However, in November of 2006 the company abruptly announced that all operations would cease by February of 2007 and most workers were to be terminated by the end of December of 2006. Only a small number of workers would remain into 2007 to close down all remaining operations on the plantation. All plants and fruit in the field were to be destroyed and a cover crop was to be planted on the fallowed lands. By the end March, most of the process of closing down the plantation had been completed and lands, which were owned by the Campbell Estate, had begun to be sold. On April 5, 2007, it was announced that Monsanto Co. would buy 2,300 acres formerly farmed by Del Monte for the company's seed corn breeding program. By the end of April a partnership between the U.S. Army and Actus Lend Lease, a developer of military housing, announced that they had jointly acquired an additional 2,500 acres of land formerly farmed by Del Monte. Some of the land was to be used for military housing and the balance was to be leased to farmers.

### **Maui Pineapple Company Announces Closure of Pineapple Cannery**

At the end of April, 2007 Maui Pineapple Company announced that it would close its cannery at Kahului, Maui at the end of June, 2007. Approximately 120 jobs will be eliminated. The company will still process juice but will focus on its more profitable premium fresh fruit business. Both fresh and processed fruit production and sales for the Hawaii industry were down in 2006 and it can be expected that they will drop further in 2007. ♦

## **News From Viet Nam**

### ***Evaluation of Ten 'Smooth Cayenne' and Seven 'Queen' Pineapple Clones Under Different Soil Conditions in Viet Nam***

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Claude Teisson (retired in Dec. 2006), CIRAD, Montpellier, France

#### **Abstract**

Two pineapple comparison experiments for yield and fruit characters were conducted for ten 'Smooth Cayenne' and seven 'Queen' clones separately in 2004-2005 in different soils in south Viet Nam. In each experiment, a split plot design was followed with locations as the main plot and cultivars as the subplot. Cayenne Thailand performed the best with regard to flowering percentage (95.0%), fruit weight (1607g) and yield (88.8 tonnes ha<sup>-1</sup>), followed by GF449 and Cayenne Lam Dong (79.0 and 78.5 tonnes ha<sup>-1</sup>, respectively). 'Smooth Cayenne' clone GF449 had excellent total soluble solids (TSS) with 17.4 °Brix and vitamin C (8.3 mg 100ml<sup>-1</sup>). 'Queen' clone GU044 was superior for fruit weight (1217g) and yield (74.7 tonnes ha<sup>-1</sup>), followed by clones RE044 and GF450 (71.4 and 70.4 tonnes ha<sup>-1</sup>). 'Queen' clone Kien Giang and Ben Luc had high TSS (17.6 °Brix) while TA039 had good fruit firmness (1.92 kg cm<sup>-2</sup>). Pooled data from three locations of each experiment were presented.

#### **Introduction**

Pineapple is an important tropical fruit of Viet Nam as it is in high demand from both local and international markets for fresh fruit as well as processed products. Cultivation of pineapple has been commercially practiced in Viet Nam for many years, and is grown on about 43,350 ha and 422,251 metric tonnes were produced in 2004. While the area planted to pineapple has expanded yearly, growers in Viet Nam still face problems. An important problem is a lack of desirable cultivars for different growing areas that are resistant to the major pests and diseases. These obstacles lead to low income for growers as compared to those in other countries. The Southern Fruit Research Institute (SOFRI) introduced pineapple clones from abroad in 1998 and clonal selection was begun in 2003. The primary breeding objective was to provide elite pineapple clones to farmers for better production. The

results of the evaluation of ten 'Smooth Cayenne' (SC) and seven 'Queen' (Q) pineapple clones under different soils are reported in this paper.

## Materials and Methods

### Experiment 1: Comparison of ten 'Smooth Cayenne' (SC) pineapple clones in three soils

The trials were carried out on three soils at Chau Thanh; Tan Phuoc Dist. (Tien Giang province) and Tan Thanh (Ba Ria-Vung Tau province) in 2004-2005. In each soil type, the 10 clones (HA10, CI09, CI036, AN38, GF449, GU114, and AU124 from France; Cayenne Thailand; Cayenne Trung Quoc from China; Cayenne Lam Dong from Viet Namnam as the check) were arranged in a randomized complete block design (RBD) with 3 replications and 80 plants/replicate. The soil properties at the three locations are shown in Table 1.

### Experiment 2: Comparison of seven 'Queen' (Q) pineapple clones in three soils

Seven 'Queen' clones were grown in 2004-2005 in trials conducted on three soils at Chau Thanh; Tan Phuoc (Tien Giang province) and Ben Luc (Long An province) (Table 1) following the procedures described for 'Smooth Cayenne' clones. Clones GU044, GU076, GF450, RE044, and TA039 were from France while Kien Giang and Ben Luc were local clones.

Table 1: Soil properties of pineapple trials.

Observation	Châu Thành (Long Định commune)		Tân Phước (Tân Lập commune)		Ben Luc (Lương Hòa commune)		Tân thành (Hạc dịch commune)	
	5.52	medium acid	3.25	high acid	592	low acid	52	medium acid
pH KCl	4.06	high acid	3.03	high acid	427	high acid	4.1	high acid
N total (%)	0.10		0.04	poor	73	poor	0.16	medium
P soluble (mg/100g)	19.90	high	11.30	medium	94	poor	4.0	poor
K exchanged (mg/100g)	17.50	high	10.05	medium	96	poor	3.18	poor
Organics (%)	4.26	high	3.04	medium	592	low acid	1.6	poor
Ca (me/100 g)	1.65	poor	0.38	poor	241	medium	0.62	poor
Mg (me/100g)	0.54	poor	0.20	poor	55	poor	1.4	poor
EC (mmhos/cm)	0.24	low salt	0.24	low salt	34	low salt	0.24	low salt

The planting density was approximately 61,500 plants ha<sup>-1</sup> for both SC and Q. All cultural practices were followed for proper production and fertilizers applied per year were as follows: CaCO<sub>3</sub> (500 kg ha<sup>-1</sup>), farm yard manure (10-12 tonnes ha<sup>-1</sup>); N (10g plant<sup>-1</sup>); P<sub>2</sub>O<sub>5</sub> (6g plant<sup>-1</sup>); K<sub>2</sub>O (12g plant<sup>-1</sup>). Flower forcing (forcing) for 'Queen' clones was by application of 50-60 ml of 2% CaC<sub>2</sub> solution over the top of the plant in early morning (6-8 a.m.) 13<sup>th</sup> months after planting when pineapple plants had approximately 40-42 leaves. For the SC clones, 60 mL of a solution containing of 2% CaC<sub>2</sub> and 2% Urea was applied at night (7-8pm) at 13<sup>th</sup> months after planting. A second application was made 3 days later. Data were collected on the number of days from forcing to harvest for the different clones (Tables 2 and 3). The data were analyzed using IRRISat 3.1 and pooled data from 3 three locations of each experiment are presented.

## Results and discussion

### Experiment 1 'Smooth Cayenne' (SC)

Flowering percentages for Cayenne Thailand (95.0%), GF449 and Cayenne Lam Dong were highest and not significantly different (Table 2). The lowest percentage flowering was found for clones HA10, AN38, CI036 and GU114, which were not different from each other (Table 2).

Average fruit weight of clone AU124 (1619g) was not different from those of clones GU114, GF449, Cayenne Trung Quoc, Cayenne Thailand, and Cayenne Lam Dong (Table 2). Clones CI036 and CI09 produced the smallest fruits. Fruit yield of clones GF449 and Cayenne Thailand were the highest though not significantly higher than that for Cayenne Lam Dong (Table 2). Clones AN38, CI036 and HA10 produced the lowest yields. The high fruit yields of GF449, Cayenne Thailand, and Cayenne Lam Dong observed in the present investigation probably are due to the high percentage of flowering of these clones. However, greater fruit weight of these clones also contributed significantly to total yield per unit area.

Differences in the top:bottom diameter ratio (T:BD) among the clones was small with only clone GU114 having a significantly lower ratio than the other clones. However, fruit shapes did differ as follows: GF449, Cayenne Trung Quoc, Cayenne Thailand and Cayenne Lam Dong were long cylindrical; CI09 and AN38 were medium cylindrical; AU124 was trapezium; CI036 was medium trapezium; and HA10 and GU114 were long trapezium. The results were consistent with findings of OCAB (2003) who reported that fruits of GF449, AU124 and HA10 were cylindrical in shape while fruits of GU114 were trapezium-shaped.

Total soluble solids (TSS) was quite high for most of the clones. Clone GF449 had significantly higher TSS than all clones but CI036. Clone HA10 had significantly lower TSS than all other clones. Clone CI09 had the highest vitamin C content among

the SC clones though it was not significantly higher than levels for Cayenne Thailand, GF449, or Cayenne Lam Dong. The lowest vitamin C content was found for clone HA10. The vitamin C content of clone CI09 in the present study was lower than that reported by the findings of OCAB (2003) who found 13 mg/100ml fruit juice for clone CI09. The highest titratable acidity (TA) values were found for Cayenne Lam Dong, AU124, GU114, AN38, CI09, and Cayenne Trung Quoc, which were not different from each other. Clones HA10 and Cayenne Thailand had the lowest TA values (Table 2).

Table 2: Yield and fruit characters of 10 'Smooth Cayenne' clones averaged over three soils in south Viet Nam.

Clone	FH, days†	Flowering (%)	F.weight (g)	Yield, T ha <sup>-1</sup>	T:B D#	TSS, %*	VitaminC, mg/100ml	TA*, g/100g
AU124	169	79,6 bcd	1619 a	68,5 bc	0,91 abc	15,8 c	8,0 bc	0,89 a
GU114	167-169	75,2 cde	1573 a	63,4 c	0,89 c	15,8 c	7,8 bc	0,89 a
GF449	167	88,2 ab	1622 a	79,0 a	0,94 a	17,4 a	8,3 ab	0,81 bc
AN38	168-169	72,5 de	1390 bc	50,6 d	0,93 ab	16,3 bc	7,8 bc	0,84 abc
CI09	165-166	82,5 bcd	1369 c	58,2 cd	0,94 a	15,8 c	9,1 a	0,88 a
CI036	167-168	73,8 cde	1359 c	48,7 d	0,90 bc	16,7 ab	7,1 cd	0,80 cd
Trung Quoc	165-166	88,1 ab	1544 ab	74,9 b	0,94 a	16,1 bc	8,2 ab	0,86 ab
C. Thailand	163-164	95,0 a	1607 a	88,8 a	0,93 ab	15,9 bc	9,1 a	0,74 de
Lam Dong	163-165	84,6 abc	1654 a	78,5 ab	0,94 a	16,0 bc	8,6 ab	0,90 a
HA10	170	69,0 e	1395 bc	48,5 d	0,91 abc	14,0 d	6,6 d	0,73 e
Population mean		809	1513	659	92	159	81	0.84
CV(%)		16.9	8.6	22.3	4.5	7.4	11	11.1

†Days from forcing of flowering to harvest

#Ratio of fruit top:bottom diameter

\*Undefined units are TSS, total soluble solids, TA, titratable acidity.

#### Experiment 2 'Queen'

'Queen' clone GU044 had the greatest fruit weight though it was not significantly greater than those for clones GU076 and RE044. 'Queen' clones Ben Luc, Kien Giang and TA 039 produced the smallest fruits (Table 3). 'Queen' clone GU044 produced the highest yield though it was not significantly greater than yields for clones RE044 and GF450 (Table 3). The lowest yield was recorded for clone TA039.

Fruits of 'Queen' clone Ben Luc had the highest T:BD ratio although it was not significantly higher than the ratios for clone Kien Giang (Table 3). 'Queen' clone RE044 had a low T:BD ratio. Fruit shape among the 'Queen' clones varied as follows: Ben Luc was medium cylindrical; Kien Giang, GU044, GU076, and GF450 were long cylindrical; and TA039 and RE044 were long trapezium. Fruit shapes reported by OCAB (2003) were cylindrical for clones GU076 and RE044 and trapezium for clones GU044, TA039 and GF450.

The 'Queen' clones had slightly higher average TSS than did the SC clones. Among the Q clones Ben Luc and Kien Giang had the highest TSS values (Table 3) while TSS for GU044 was slightly but significantly lower. Clones GU076, RE044, TA039, and GF450 all had significantly lower TSS values. Clone TA039 had the highest fruit firmness value though it was not significantly different from values for Ben Luc, Kien Giang and GF450. Clone GU076 had the lowest firmness value while the values for the other cultivars were intermediate (Table 3). OCAB (2003) also found a high fruit firmness value for TA039, and medium values for GF450 and GU076.

All of the 'Queen' clones had higher vitamin C content than did the SC clones. 'Queen' clones Ben Luc, GU076, GU044, TA039 and GF450 all had high vitamin C contents. Clone RE044 had a very low vitamin C content and perhaps due to that low value, the CV for vitamin C among the Q clones was somewhat higher than that for the SC clones. Average titratable acidity for the Q clones was lower than for the SC clones and the CV for the Q clones also was slightly lower than that for the SC clones. The highest TA values were found for Q clones Kien Giang and Queen Ben Luc though they were not significantly greater than values for clone GU076. Clone RE044 had low acid in the fruit.

#### Conclusion

'Smooth Cayenne' clones such as Cayenne Thailand, GF449 and Queen varieties GU044, RE044, and GF450 were found to be superior to the other clones tested for production in south Viet Nam. However, further larger scale testing is needed fully evaluate the stability of these clones.

#### Reference

OCAB (Organisation Centrale de Producteurs Exportateurs D'ananas et de Bananes de Cote D'Ivoire), 2003. Fich de synthese pineapple fruit (141)



Table 3: Yield and fruit characters of 7 'Queen' clones averaged over three soils in south Viet Nam.

Clone	FH, days†	F.weight (g)	Yield, T ha	T:B D#	TSS, %*	Firmness (kg/cm <sup>2</sup> )	Vitamin.C, mg/100ml	TA*, g/100g
Ben Luc	140-143	877 c	66,7 bc	0,93 a	17,6 a	1,89 ab	12,9 a	0,79 a
Kien Giang	140-142	944 c	61,2 c	0,92 ab	17,6 a	1,8 a-d	10,8 bc	0,80 a
GU076	147-149	1129 ab	66,2 bc	0,89 cd	15,7 c	1,63 d	12,6 ab	0,72 ab
GU044	146-148	1217 a	74,7 a	0,90 bc	16,6 b	1,68 cd	10,9 abc	0,67 bc
RE044	144-145	1129 ab	71,4 ab	0,87 d	15,8 c	1,72 bcd	9,5 c	0,63 c
TA039	142-143	965 c	54,3 d	0,91 bc	15,5 c	1,92 a	11,5 abc	0,67 bc
GF450	150-151	1071 b	70,4 ab	0,90bc	15,3 c	1,84 abc	11,3 abc	0,68 bc
Pop. mean		1047	66.4	0.9	16.3	1.78	11.4	0.71
CV(%)		11.6	10.4	2.1	3.5	10.7	14.5	10.2

†Days from forcing of flowering to harvest

#Ratio of fruit top:bottom diameter

\*Undefined units are TSS, total soluble solids, TA, titratable acidity.◆

## Reviews of Books and Book Chapters

No reviews provided for this issue.

## Notices

### Commercial Services

**Maintain CF 125** continues to be available for use in pineapple plant propagation. A renewal letter for registration of the product was received in 2003. For further information, contact Bhushan Mandava, Repar Corporation, P.O. Box 4321, Silver Spring, MD 20914 Tel: 202-223-1424 Fax: 202-223-0141; E-Mail: [mandava@compuserve.com](mailto:mandava@compuserve.com)

### Commercial Sources of Pineapple Plants Propagated by Tissue Culture

**Centro de Bioplasmas.** Dr. Justo L. Gonzalez Olmedo, Director of Foreign Affairs Office, Centro De Bioplasmas. Universidad De Ciego De Avila, Carretera a Moron Km 9. Cp69450. Cuba. Centro De Bioplasmas offers certificates of authenticity for pineapple material propagated in their tissue culture facility. Web site: <http://www.Bioplasmas.cu>

**LAMERSA**, Dole's meristem laboratory in Honduras. Contact John T. Mirenda PhD, Dole Fresh Fruit International Ltd., San Jose, Costa Rica. Phone: 506 287 2175. Fax: 506 287 2675. E-mail: [Jmirenda@la.dole.com](mailto:Jmirenda@la.dole.com). The laboratory can produce meristematically-derived plants of pineapple as well as banana and other crops.

**Vitropic**, Zone d'Activités Economiques des Avants, 34270 Saint Mathieu de Trévières France; Tel: + 33 (0)4 67 55 34 58; Fax: + 33 (0)4 67 55 23 05. E-mail : [vitropic@vitropic.fr](mailto:vitropic@vitropic.fr). Web site: [www.vitropic.fr](http://www.vitropic.fr). Vitropic proposes the best individuals from the CIRAD FHLOR selected clones including: Cayenne Group, Queen Group, Perolera Group, MD2, Ornamentals pineapples. The range is continuously extending, do not hesitate to ask for more information.

### Directory of Professionals

This listing is maintained as a convenience for those seeking assistance from professionals with experience in pineapple production and processing. If you have such expertise and are able to provide consulting services, please send you rname, address, E-mail address, and areas of expertise to D.P. Bartholomew ([duaneb@hawaii.edu](mailto:duaneb@hawaii.edu)).

**Dr. Mark Paul Culik.** INCAPER, Rua Alfonso Sarlo 160, CEP 29052-010, Vitoria, ES, Brazil; Tel: 27-3137-9874; [markculik3@yahoo.com](mailto:markculik3@yahoo.com). Experience: PhD in Entomology with more than 25 years of agricultural pest management experience in crops ranging from apples to papaya and pineapple, identification of pests and beneficial arthropods ranging from Collembola to fruit flies, and current work on scale insects with emphasis on pineapple mealybugs. Areas of specialization: Entomology, Insect and Pest Identification, Integrated Pest Management.

**Dr. Francisco Gomez** (E-mail: fgomez1@cablecolor.hn) and **Jose R. Vasquez**, MBA (E-mail: jrva46@excite.com). Golden Pacific Ag Services, P.O.Box 15088, Lomas Miraflores, 4a. Calle, 1a Avenida # 4326, Tegucigalpa, Honduras. Phone: 504 230 1120; 504 969 5568. Experience: Pineapple and melon production, from seed propagation-planting-field maintenance-forcing-harvesting-post-harvest management and commercialization.

**Ian Greig**, Greig and Associates, P.O. Box 273508, Tampa, FL 33688. Phone: (813) 908-7698; Fax: (813) 963-6229. E-mail: [iang@ag-consult.com](mailto:iang@ag-consult.com). Web site: [www.ag-consult.com](http://www.ag-consult.com). Services for all phases of pineapple production but emphasis is on pineapple industry and market analysis.

**L. Douglas MacClure**. 360 Hoopalua Dr., Pukalani, Hawaii, U.S.A. E-mail: [norfolkldm@aol.com](mailto:norfolkldm@aol.com). Experience: More than 39 years with Maui Pineapple Company heading plantation and diversified agriculture operations and started the Royal Coast Tropical Fruit Company in Costa Rica. Collected and summarized production information in Asia and Central America. Also consulted on pineapple for companies and growers in El Salvador, Australia, Thailand and Indonesia.

**Mr. Graham J. Petty** 7 Anglers Way, Port Alfred, 6170 Republic of South Africa. Phone: +27 (0) 46 624 4868; Tel/Fax: +27 (0) 46 625 0946; E-mail: [grahamp@imaginet.co.za](mailto:grahamp@imaginet.co.za). Experience: M.Sc. (Agric) Pretoria. Researcher and advisor to the South African Canning Pineapple Industry on matters of Pest Management in pineapple culture, for 34 years. Economic entomology and management of biological control agents have received particular attention.

**Dr. José Aires Ventura**. Incaper, Rua Afonso Sarlo 160 (bento Ferreira), 29052-010, Vitoria-ES, Brazil. E-mail: [ventura@incaper.es.gov.br](mailto:ventura@incaper.es.gov.br); Tel.: 55-27-31379874. [www.incaper.es.gov.br](http://www.incaper.es.gov.br). Area of Specialization: Plant Pathology (research in pineapple diseases management; Fusarium diagnosis, diseases resistance).

**Dean Wheeler**. AgResults Inc., 609 Buchanan Street, Davis, California, U.S.A. 95616. Phone/fax: 530-758-4620 Residence: 530-758-3354 Email: [agresults@aol.com](mailto:agresults@aol.com). Web page at <http://agresults.com/index.html>.

## Web Sites of Possible Interest

Annual Reports of the Hawaii Agricultural Research Center (HARC) at <http://www.hawaiiag.org/harc/HARCPB13.htm> provide information on biotechnology programs, including work on pineapple. Research on pineapple is reported in annual reports for 2001-02 and onward.

USDA ARS Hawaii Pineapple Improvement Project. The outline of the proposed research and a link to the 2006 Annual Report can be found at: [http://www.ars.usda.gov/research/projects/projects.htm?accn\\_no=410039](http://www.ars.usda.gov/research/projects/projects.htm?accn_no=410039). ♦

## References

This list includes papers published or located since the last issue of the newsletter was printed. Reprints of many of the publications listed below can be obtained from the authors, are obtainable from most research libraries, or from Library External Services, Hamilton Library Room 112, University of Hawaii, 2550 The Mall, Honolulu, HI 96822 U.S.A.; contact the library for current charges.

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## Contributions to Pineapple News

All contributions should be written in English. We will gladly provide assistance with editing.

Preferred contributions include:

- Timely news about research on issues related to culture, processing, storage, and marketing of pineapple.
- New, interesting, or unique problems encountered by growers.
- Country or status reports on the local pineapple industry.
- If uncertain about the suitability of material for the newsletter, contact the editor.

If possible, please send contributions by E-mail as attached files in MS Word or rich text format or on floppy disks. When sending

printed copy, be sure that it is clean and sharp so it can be scanned to speed conversion to a wordprocessor format.

**Article length:** Papers should be no longer than 4 double-spaced pages in 12 point font or equivalent, not including tables, figures and photos. If longer than 4 pages, please contact the editor. There is no limit on the number of articles that can be submitted. However, acceptance and publication is at the discretion of the editor.

**Tables:** The preferred table format is columns separated by tabs. Authors may be asked to revise tables not in the requested format.

**Photographs:** Submit photographs that can be scanned or provide digital files in jpeg format with a minimum resolution of 300 dpi so they can be printed with acceptable resolution in grey scale with a laser printer.

Mail contributions and inquiries to: **D.P. Bartholomew, Dept. of NREM, Univ. of Hawaii, 1910 East-West Rd., Honolulu, HI 96822 U.S.A.** (Phone (808) 956-7568; Fax (808) 956-6539; E-mail: [duaneb@hawaii.edu](mailto:duaneb@hawaii.edu)).

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